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CINEMANALYSIS: A METHOD OF BEHAVIOR STUDY*

From the Yale Clinic of Child Development

ARNOLD GESELL

The cinema makes available for study (*a*) the behavior moment, (*b*) the behavior episode, and (*c*) the developmental epoch. The behavior of the human infant is fundamentally ordered by ascertainable, though poorly understood, laws of growth. Behavior is moulded into characteristic forms by virtue of these laws of growth. And such forms, whether statically or dynamically regarded, may be investigated from the standpoint of a developmental morphology. Cinematographic methods are indispensable for such investigation. Elsewhere we have indicated the general significance of cinema data for comparative and genetic studies (1-4). The present paper deals more specifically with the principles of cinemanalysis.

It is interesting to recall that the development of cinematography has been closely associated with an interest in the problems of animal and of human motion This is the centennial year of photography. In 1834 Daguerre announced the fundamental process which lies at the basis of the cinema The study of motion was necessarily delayed because to make a single exposure on one of Daguerre's metal plates consumed fully 20 minutes of time. But in 1861 Sellars, an ingenious inventor of Philadelphia, was using a more nearly instantaneous photographic process to take a series of pictures of his son in the act of driving a nail These pictures represented successive phases of a behavior event. By placing the individual photographs on a paddle-wheel device, he reproduced the impression of motion. The paddle wheel was more or less on the principle of numerous optical toys, variously named kinetoscope, phasmatrope, stroboscope, zoetrope, zoopraxascope, etc They were peep-show, whirl-a-gig devices, one of them was called the Wheel of Life.

In time they proved to be more than toys Miles (6) has given us an interesting account of the motion study laboratory set up at Palo Alto in the later environs of Leland Stanford Junior Uni-

*Based on a paper read at the First Biennial meeting of the Society for Research in Child Development at Washington, D. C

versity. This laboratory was the result of the senior Stanford's keen inquisitiveness about the details of the stride of a galloping horse He had a breeder's interest in the problem. He enlisted the services of Eadweard Muybridge. Muybridge, with the help of John Dove Isaacs, a mechanical engineer who devised the electrical equipment, erected a row of 24 cameras parallel to a running field across which the race horse galloped. Twenty-four double focal-plane *shutters, one for each camera,* were released in rapid succession. Twenty-four wet plates were developed and 24 individual photographs were inserted in Senator Stanford's stroboscope.

In the early 90's, as a result of the combined efforts of Edison and of Eastman, such successive photographs were for the first time made upon a continuous flexible film which was projected in successive flashes upon a motion picture screen. Silent cinematography had arrived. Still later sounds and speech were incorporated into the cinema film

This remarkable technological advance has made cinematography a powerful instrument for scientific investigation. For example, eight feet of 16-mm. film embodies 320 individual, seriated photographs or frames, recording and reproducing 20 seconds of behavior.

Cinemanalysis consists in an analytic study of such individual frames or chronophotographs. A chronophotograph may be defined as one of a series of photographs of a moving object taken for the purpose of recording and exhibiting successive phases of motion.

Cinemanalysis, as a method of investigation, is made possible by five fundamental features of technique, as follows:

1. The film being propelled at a known speed minutely records time values and sequences.

2 Simultaneously and also minutely the film records space relationships and configurations.

3. The film records these spatial and temporal data in a series of discrete, instantaneous registrations.

4. These registrations can be serially reinstated at normal, retarded, and accelerated rates.

5. Any single registration can be individually studied, in terms of time and space, as a delineation of a single phase of a behavior pattern or a behavior event.

These five propositions are extremely simple but their methodological implications for objective behavior study are far reaching. We

can illustrate these implications on three levels of analytic observations: (1) Slow Motion Study. (2) Selective Pattern Phase Analysis (3) Minute Pattern Phase Analysis

For the sake of concreteness our comments will be directed to actual demonstration materials, indicated by the accompanying illustrations.

1 *Slow Motion.* (A slow motion picture of a pair of infant hands, manipulating a cube, was shown See Figure 1.) This

FIGURE 1
TWO FRAMES SELECTED FROM A SLOW-MOTION CINEMA RECORD, DEPICTING THE TRANSFER OF A CUBE BY A 36-WEEKS-OLD INFANT

picture delineates the patterns of manipulation in slowed motion In the original record 32 "chronophotographs" were taken each second These frames are projected, however, at the rate of 16 per second, giving an impression of deliberate motion Eighteen seconds of behavior are shown in 36 seconds of time. Slowed motion is, in a sense, a method of cinemanalysis It permits a more intimate and more complete view of any pattern of motion. You can indeed see more deeply than with the unaided eye. And of course you can see the same film twice, thrice, or a score of times With this technological reinforcement you are at a great advantage, for without the cinema you can see the living child perform a given act only once

But even slowed motion is too elusive The only successful way to study motion is to stop it But the stoppage of a film moving through the channel of a projector presents mechanical difficulties and practical inconveniences which are not altogether overcome by a moviola The stilling devices of a commercial projector proved unsatisfactory for laboratory analysis. It was awkward to work with images on an upright screen For systematic study it was necessary to make the images more accessible and to bring them under more intimate control

These needs have been met by a desk type of projector described by Halverson (5) Our latest model of this desk projector embodies several mechanical features which increase the flexibility of cinemanalysis. Each frame is automatically registered by a counter as it passes through the projector This projector can be operated continuously by motor in forward or reverse Or it can be operated intermittently by hand, forward and reverse, at slow or fast rates The image is projected upon a ground glass window of the sloping desk This permits convenient inspection.

Once the film is in the projector, the operator may freeze or activate the behavior to suit his observational fancy (and obtuseness) The behavior record becomes as pliant to dissection as a piece of tissue Any phase or strand of behavior may be exposed to view If the view is an intricate one it may be repeated numerous times without in any way damaging the original record Here the dissection of behavior forms has a striking advantage over anatomical dissection Bodily tissue suffers from the scalpel, but the integrity and conformation of behavior cannot be destroyed by repeated observation A behavior form can be dissected over and over again in increasing detail without loss of form

If one projects the individual frames (chronophotographs) on the projection desk at the rate of one per second, one gets a staccato succession of intermittent stills. If two frames per second are projected, one gets an illusion of slowed but confluent motion This rate gives one a good analytic grip on the data under observation When the grip falters, one simply reverses the crank and then views the sequence again.

This type of slowed motion should of course be distinguished from the type of slow motion which has already been illustrated Slow-motion photography is based upon an increase in the number of individual frames recorded per second. Such multiplication of frames therefore increases the minuteness of the original record In the physics laboratory the astounding number of 6,000 discrete exposures per second has been attained. The ordinary problems of behavior analysis do not require such a degree of refinement Sixteen frames per second furnish an almost inexhaustible detail of behavior delineations. For intensive experimental analyses, depending on the nature of the problem, the number of frames per second can be profitably increased

2. *Selective Behavior Pattern Phases.* It is now evident that in degree of detail cinemanalysis can be adjusted to suit the requirements of the problem in hand and the interests of the observer. For cinemanalysis, it must not be forgotten, *is* a method of observation. Because of the very comprehensiveness of the data under scrutiny, the observer must finally select those phases which are pertinent to his investigation of the morphology or of the dynamics of behavior.

For illustration, consider 20 seconds of the behavior of a 20-weeks-old infant. The infant has been normatively selected. He lies supine. The examiner, with standardized procedure, slowly brings a rattle above the infant's chest to elicit visual fixation and prehensory reactions. The behavior episode is fully recorded in 8 feet of 16-mm. film which at normal speed can be observed in 20 seconds. In one hour of actual observing duration, it could be seen 180 times.

Depending upon the kind and amount of observation expended, the behavior episode may be described in a single phrase, in a single sentence, or in a single paragraph, or in several paragraphs, or in an exhaustive inventory of detailed analytic items. In the pictorial delineations of *An Atlas of Infant Behavior* (4) a behavior situation of this type is depicted in eight selected cinema frames, corresponding to eight salient pattern phases of the entire behavior episode. This series of eight photographs, together with the associated text, reconstructs the essential features of the infant's behavior. The textual description is reproduced below:

RATTLE SITUATION 20.0 seconds 8 phases

A 0.25 seconds *Rattle is presented in midplane over chest.* 0.25 Infant lies supine, head in midposition, trunk straight, arms flexed, closed hands engaged on chest; legs acutely flexed in outward rotation, feet in contact 2 inches above platform. Regards rattle.

B 4.25 seconds Lifts forearms over chest, opening hands, fingers in contact. 3.25 Turns head half right, swinging shoulder toward right and pelvis toward left, regards surroundings. 5.75 Closes right hand. 6.0 Turns head to midposition, straightens shoulders, pelvis remaining deviated to the left. Regards rattle. 7.0 Semi-extends arms over chest, hands in contact. Yawns.

C 9.0 seconds Separates hands, semi-extending arms vertically in lateral chest zone, opens right hand. 10.75 Semi-extends right arm headward on platform. 12.25 Semi-extends arms medially over chest, hands approaching rattle

D 13 0 seconds Grasps rattle in right hand, flexing fingers over handle; dorsum of left hand touches right hand 13.75 Extends left arm somewhat medially over abdomen, hands separating 14.25 Semi-extends right arm laterally, forearm lifted slightly above platform.

E 14 75 seconds. Turns head half right, turning shoulders toward right, pelvis deviated toward left.

F 15 75 seconds. Semi-extends left arm medially across chest toward rattle in right hand. 16 25 Flexes right arm, lifting forearm vertically in lateral chest zone. 16 75 Hands engage over right chest.

G 17 75 seconds. Flexes arms, directing forearms medially over chest and lifting rattle to mouth Regards surroundings 19 0 Holds rattle over chest; turns head to midposition 19 5 Straightens shoulders, pelvis deviated to left Regards rattle.

H 20.0 seconds. Separates hands, lifting right forearm vertically in lateral chest zone, opens right hand, dropping rattle between knees, semi-extends left arm medially over abdomen, hand on left knee. Regards Examiner (20 sec)

The foregoing text, in conjunction with the eight delineative photographs, gives us a relatively complete picture of the entire behavior sequence. If the investigator had chosen to explore only one aspect of the behavior, like visual regard, head movements, or leg activity, he would still have used the same method of selecting significant pattern phases. The detail and thoroughness of such selection would depend upon scientific objective and practical convenience.

3. *Minute Pattern Phases*. In order to demonstrate the wealth of behavior content which is contained in a single situation, we have made a frame-by-frame analysis of this particular cinema record. The 16-mm. film for 20 seconds of behavior is eight feet long and consists of 320 frames. Each frame was individually inspected with regard for every member of the body. Behavior pattern phases were determined for head, eyes, mouth, right arm, right hand, right fingers, left arm, left hand, left fingers, thorax, pelvis, right leg, right foot, right toes, left leg, left foot, left toes. For purposes of classification, these behavior phases fell into three categories: (*a*) *a critical phase* in which the member is at rest or undergoes a complete shift or reversal of movement, (*b*) a *kinetic phase* when the movement is under way, (*c*) *a phase of resolution* or culmination when this particular movement is completed or resolved.

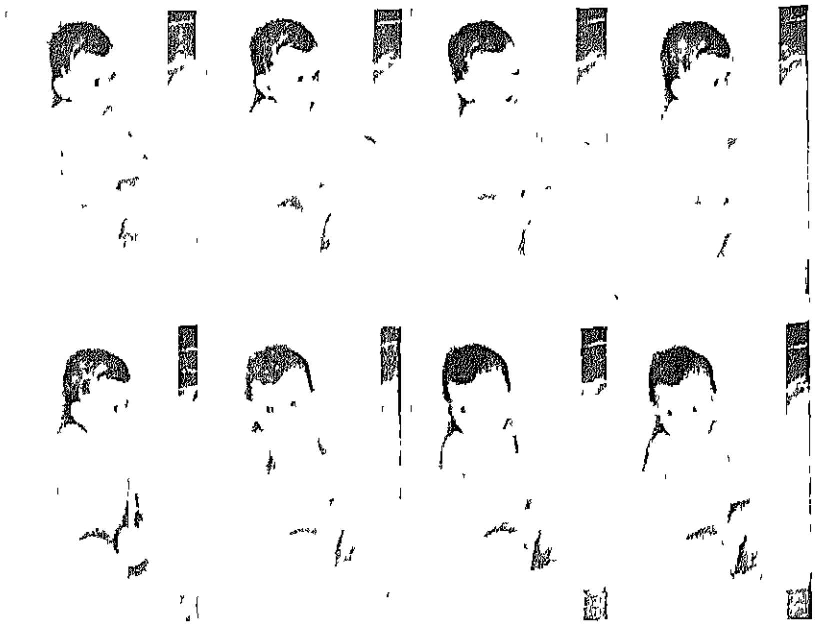

FIGURE 2

EIGHT FRAMES (CHRONOPHOTOGRAPHS), DELINEATING EIGHT PHASES OF TWENTY CONSECUTIVE SECONDS OF BEHAVIOR

These are as follows (reading the pictures from top to bottom): *A*, 0.25 seconds; *B*, 4.25 seconds; *C*, 9.0 seconds; *D*, 13.0 seconds; *E*, 14.75 seconds; *F*, 15.75 seconds; *G*, 17.75 seconds; *H*, 20.0 seconds.

This analysis yielded a total of 360 pattern phases, which are tabulated in Table 1 for each of the 17 body members and each of the 20 seconds. Even the bare table for this brief interval of behavior discloses certain dynamic trends. To determine pattern characteristics, however, it would be necessary to study the data in scatter diagram array, in time-space terms, and ascertain the sequences, synchronization, and directions of movement. The bare figures are presented here, without interpretation, simply to show the striking degree to which cinemanalysis can augment the scope and the certitude of observation. A total of 360 behavior data within a time span of 20 seconds attests the refractive power of cinemanalysis as an aid to scientific observation.

TABLE 1 (*continued*)

	11	12	13	14	15	16	17	18	19	20
Head			k r c	k	r	k				k rr c
Eyes	c kk rr	c		c k r	k r					
Mouth										
R. arm	kk rr	k rr		kk	kkk rrr	r		kk	k	kk rrr
R hand	c k r	kk r	r	kk r	r	k	k	r	c k	k rr
R. fingers	c kk	kk rr	r						k	k rr
L arm	r	kk r c	k c	k rr	k	r c			k	k r c
L hand	r	kkk r c		kk c	kk r	r c	c			k r cc
L fingers		k			k r c			k	k r	k rr

TABLE 1 (*Continued*)

	11	12	13	14	15	16	17	18	19	20	
Thorax										k r	
Pelvis					k r						
R leg		kk rr									
R foot		k r		k r c							
R toes		kk rr	k r								
L leg		kk rr									
L foot	c k r	k r	k r	k r						k r	
L toes	kk rr	kk r	k r	k r						kk rr	
No (c) critical	4	3	2	3	1	2	1	0	1	4	59
of (k) kinetic	10	21	5	12	9	2	1	3	5	12	167
Phases (r) resolution	10	16	6	7	9	3	0	1	1	17	134
Totals	24	40	13	22	19	7	2	4	7	33	360

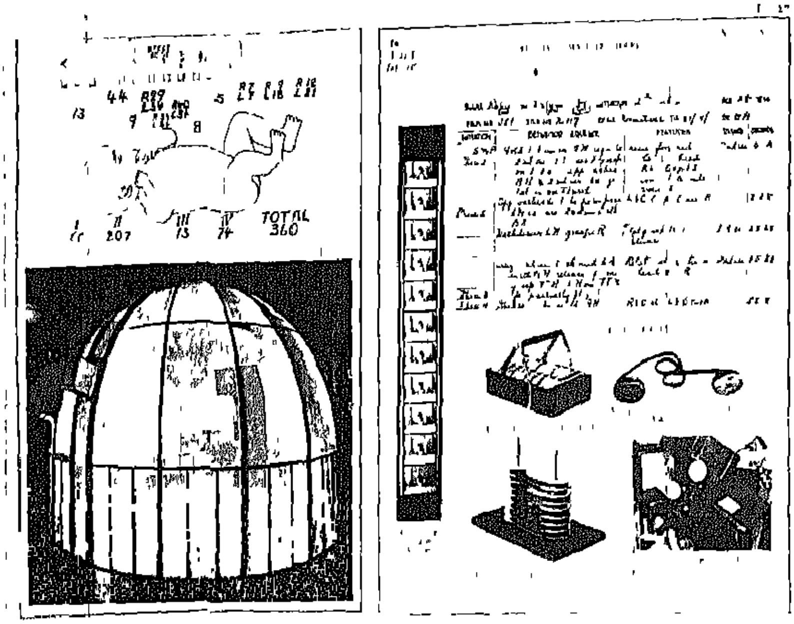

FIGURE 3

A Pictorial Summary of Cinemanalysis Procedures

This shows, (1) photographic observation and recording dome by which the cinema records were secured, (2) a specimen section of 11 frames from a 16-mm. cinema record; (3) the analytic projection desk for the study of the records, (4) tray in which reels are filed and carried, (5) a single reel with take-up reel ready for insertion in analytic disk, (6) a double spindle rack for give and take reels, assembled for serial or comparative study; (7) a specimen record of a behavior pattern analysis, (8) a diagram of a supine infant (upper left hand corner), showing behavior pattern phases for the four body segments, as detailed in the text, namely I, Head, II, Upper limbs, III, Trunk, IV, Lower limbs

The diagram, Figure 2, gives a further indication of the prodigious complexity of behavior events when they are placed under the high power of frame-by-frame analysis. The behavior components are so numerous that they attain statistical magnitudes in a very brief interval The diagram divides the activity of the infant into four behavior segments: I Head, II Upper Limbs, III Trunk, and IV Lower Limbs We find that the pattern phases distribute them-

selves with reference to these segments as follows. I head 13, eyes, 44, mouth 9, total 66, II right arm 40, right hand 34, right fingers 29, left arm 34, left hand 36, left fingers 34, total 207; III. thorax 8, pelvis 5, total 13; IV. right leg 7, right foot 9, right toes 12, left leg 7, left foot 18, left toes 21, total 74. Grand total 360.

It is not suggested that the multiplication of analytic minutiae will in itself advance our comprehension of behavior But it can be safely stated that there are fundamental problems of behavior form and behavior dynamics which will not be solved until we systematically penetrate those minute manifestations which are made visible only through the microscopy of cinemanalysis.

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L'ANALYSE CINÉMATOGRAPHIQUE UNE MÉTHODE DE L'ÉTUDE DU COMPORTEMENT

(Résumé)

L'analyse cinématographique est une méthode fondamentale pour l'observation et l'étude des phenomènes du comportement Le film cinématographique cède des données morphographiques pour l'étude (*a*) d'un seul moment du

comportement, (*b*) d'un épisode entier du comportement; (*c*) d'une succession *développementale ou cyclique. A l'aide d'un bureau spécialement construit qui comprend un projecteur* opéré à la main (et mis en marche par un moteur), il est possible de restaurer en série les phases enregistrées du comportement à des vitesses normales, retardées et accélérées. La possibilité d'une inspection répétée du comportement original *donne un pouvoir* unique de dissection à *cette méthode.* On peut étudier les enregistrements du comportement à trois niveaux d'analyse. (1) la motion ralentie; (2) l'analyse sélective des phases des formes, (3) l'analyse minutieuse des phases des formes. Les principes généraux de l'analyse cinématographique à ces trois niveaux sont *illustrés par des chronophotographies* et un diagramme. Vingt secondes du comportement sont analysées en détail dans un cliché après l'autre, cédant un total global de 360 phases de formes. Ces phases sont résumées avec de courtes observations pour indiquer la pénétrabilité microscopique de *l'analyse cinématographique La méthode* est indispensable pour l'investigation des problèmes fondamentaux dans la dynamique et la morphologie de la forme du comportement.

GESELL

KINEMATOANALYSE: EINE METHODE ZUM STUDIUM DES VERHALTENS

(Referat)

Kinematoanalyse ist eine Grundmethode zur Beobachtung und zum Studium des Verhaltens. Der Kinematofilm verschafft morphographische *Daten zum Studium eines (a) einzelnen Augenblicks des Verhaltens, (b)* einer ganzen Verhaltungsepisode, (*c*) einer Entwicklungs- oder zyklischen Reihenfolge. Vermittelst eines besonders gebauten Pultes, der einen handbewirkten (auch mit Motor versehen) *Projektionsapparat besitzt,* ist es moglich, die aufgenommenen Verhaltungsphasen zu normalen, gehemmten, und beschleunigten *Geschwindigkeiten reihenweise wiederzugeben Die* Möglichkeit einer wiederholten Betrachtung des ursprunglichen Verhaltens verleiht dieser Methode einmalige zerlegende Kraft. Verhaltungsaufnahmen können bei drei Niveaus der Analyse studiert werden. (1) bi verlangsamter *Bewegung; (2) bei auswahlender Musterphasenanalyse,* (3) bei kleiner Musterphasenanalyse Die allgemeinen Grundsätze der Kinematoanalyse auf diesen drei Niveaus werden durch Chronophotographien und Diagramme illustriert Zwanzig Sekunden des Verhaltens werden Bild um Bild *in allem Detail analysiert,* was eine Gesamtsumme von 360 Musterphasen ergibt. Diese Phasen werden mit einer kurzen *Anmerkung zur* mikroskopischen Eindringung der Kinematoanalyse zusammengefasst Die Methode ist zur Untersuchung der Grundprobleme in der Dynamik und *Morphologie des Verhaltungsmusters* unentbehrlich

GESELL

THE EFFECT OF RESTRICTED PRACTICE UPON THE REACHING, SITTING, AND STANDING OF TWO INFANTS*[1, 2]

From the Psychological Laboratory of the University of Virginia

WAYNE DENNIS

INTRODUCTION

Except when he is asleep, the young infant is almost continually active There are those who would have us believe that this activity contributes almost nothing to the child's behavioral development, and that new items of behavior make their appearance as the result of something called maturation.

The simplest way of testing this theory would be somehow to keep the infant inactive. This would involve the use of drugs in a manner analogous to Carmichael's experiments upon tadpoles Obviously, such an experiment cannot be performed. However, it is quite practicable to prevent the occurrence of *certain kinds* of activities One can deprive the infant of all objects for which he may reach, or one may refuse to place him in a sitting or standing position, and one may find the result of such deprivation of normal activities upon what Watson has called the stream of behavior.

The present paper reports such a study. Mrs Dennis and I reared two infants from the end of the first to the end of the fourteenth calendar months of life under conditions of full experimental control Our full study is to be reported in a series of papers of which this is the first member (For related material, see references 1, 2, 3). The present report is restricted to the study of grasping, sitting, and standing

*Accepted for publication by Carl Murchison of the Editorial Board and received in the Editorial Office, February 8, 1935

[1]This paper, in abbreviated form, was read before the Southern Society for Philosophy and Psychology at Birmingham, Ala, March 30, 1934

[2]I wish to acknowledge the aid of the Institute for Research in the Social Sciences of the University of Virginia, which was indispensable to this research It will be obvious from the text that Mrs Dennis was also an indispensable factor Her contribution was something considerably greater than the care of the infants but I cannot induce her to become the co-author I wish to express my appreciation to Dr L T Royster and to Miss Rose Williams of the University of Virginia Hospital for their many kindnesses.

Subjects and Procedure

Our subjects were fraternal twins, but the relationship of the infants is not an important part of the study Our original plan envisaged the use of only one subject, but the first inquiry for a subject to the Social Service Department of the University of Virginia Hospital revealed an opportunity to secure a pair of non-identical female twins The proffered twins were accepted because they enabled us to double the number of our subjects with considerably less than a doubling of cost and care. Thus the twin relationship of the subjects was, from the standpoint of our problem, purely accidental.

Their parents are of North-European ancestry. The father is a taxi-driver The mother, while at present unemployed, has been a saleswoman in department stores The father has no other children, the mother has two children by a former husband and these children are normal American urban children We were able to obtain the babies as subjects because the father failed to provide for them. The mother understood that we offered temporary care of the twins in return for the privilege of studying them She understood the nature of our studies, and was most cooperative throughout.

The twins were born in the University of Virginia Hospital where they remained for eight days. They were then taken to the home of relatives. On the 36th day they were removed to a room in our own home which was especially prepared for the experiment. They remained either in this room or in a similar one in a summer cabin until the 428th day, or the end of the fourteenth calendar month of age (the end of the fifteenth lunar month) The children were born January 19, 1932, and the experiment ended March 22, 1933

The diet of the subjects was chosen with the advice of Dr L. T Royster of the Pediatrics Department of the University of Virginia Hospital. During the early months the diet of the twins consisted of lactic acid milk, which was kindly prepared for us by the Hospital staff, and of orange juice. Soup, cereal and strained fruits and vegetables were introduced gradually during the seventh calendar month.

Although the twins were taken from their room very seldom, sun baths were given them daily before an open window, and their skin

was tanned throughout the experiment. Cod liver oil and haliver oil were given occasionally but not daily. A daily serving of orange juice was given throughout the experiment. Diphtheria toxoid was administered during the tenth calendar month but no other inoculations were applied. Throughout the experiment the babies lived in individual Kiddie-Koops, 40¼" long, 24½" wide and 20" deep.

The entire care of the infants, except for a few vacation days, was administered by Mrs. Dennis and myself, so that we were in a position to know our subjects very thoroughly, and to carry out the experimental restrictions which we desired.

Every one of the restrictions upon practice was introduced at the beginning of the experiment but none of them was continued throughout the entire period of the study. In general, a restriction of practice was removed as soon as the fact was established that it had or had not affected the response which we expected that it might.

In order to limit activities which might lead to the development of grasping, no toys were introduced until the subjects were eleven months of age. The subjects were prevented from reaching for food by placing their hands under a tightly held bib or napkin while they ate. Bed-clothes were absent when the room was warm or were tucked in so tightly that they could not readily be played with when the temperature demanded their presence.

To restrict practice which might influence sitting, the infants were kept almost continually on their backs in their cribs. For many months they were raised out of the recumbent position only slightly even when in the tub or when feeding. Until tests described in later sections were made, the subjects were never placed on their feet, or held upright against an adult's chest with an opportunity to push their feet against the adult's lap.

During the first six months we kept a straight face in the babies' presence, neither smiling nor frowning, and never played with them, petted them, tickled them, etc., except for routine tests for social smiling and for laughing made in the fifth month. Likewise, for the first six months we did not speak to the babies or use our voices in any way which might associate our vocalizations with the care of the babies, although we spoke freely to each other when in the infants' room. Thereafter, however, we behaved more normally, often talking to them and romping with them.

The door to the nursery was kept shut, and the babies could see only the persons who entered the room. Throughout the experiment the cribs were separated by a low screen so that they could see each other only when they were out of the cribs, or, at a late age, when they were standing in the cribs

The babies could see tree tops and sky through the windows of the room but nothing else was in their view. No pictures were in the room, no ornaments, carvings, etc, of any kind, and no mirror. Of furniture there was only a table, chairs, and chest of drawers

Visitors were admitted but were required to adhere to the conditions prevailing at the time of the visit.

Until the last few months of the experiment we conscientiously gave identical treatment to the two subjects. This was even carried to the extent of exchanging their beds each day and of daily alternating the baby which was to be fed by each experimenter. The two infants were fed simultaneously by the two experimenters.

While we have little information of a scientific sort concerning the care which American infants receive, it is my belief that the deprivations of practice just outlined are greater in degree than those of any children from which the normative data of other authors have been obtained [8]

The subjects were subjected to experiments of other kinds in addition to the deprivations of practice just described These other experiments will be reported separately. They did not violate the conditions laid down for the pursuit of the present problem, but the fact of their performance means that the babies were much busier than the preceding account in itself would indicate.

STATISTICAL CONCEPTS

The socio-economic status of the subjects, their ancestry and inheritance, are certainly represented in normative studies of infant behavior. That is, the subjects were not selected in any abnormal way In consequence, unless someone can show them to be patho-

[8] At one time I thought I had found a case of deprivation of practice equal to ours in a mountain infant, who, because of the severe winter was apparently always kept tightly bundled up in bed. However, upon visiting the home at nursing time I found that at this time the infant was given considerable training in sitting and standing. The infant developed the usual behavior items before the upper limits set by normative studies.

logical, we must believe that had they been reared in a non-experimental American environment they would almost certainly have performed the usual responses within the usual age ranges set by normative studies.

Evidence of their essential normality in health and constitution will be presented later. If this evidence is convincing, it follows that any retardation of the subjects beyond the upper age limit of non-pathological American children in respect to the appearance of responses must be attributed to the experiment. In other words it is held that if retardation of behavioral development occurs, our experimental conditions have caused it. The evidence for retardation is the postponement of a response beyond the upper limit set by normative researches. Just what amount of retardation the experiment produces cannot be said because it cannot be told exactly when responses would have appeared under non-experimental conditions; it can only be said that they would have occurred at some age between the upper and lower extremes as determined under non-experimental environments.

It should be understood that the amount of postponement beyond the upper limit which may be found does not indicate the full extent to which unlimited adherence to our routine care would have affected the subjects. As soon as it was clear that a response had not been developed within the usual age limits, we tried to establish it by training the child. Without this training, the response might have appeared at a much later date, or not at all.

I have spoken above as if the normal limits of the age of appearance of a given response are quite definite. This is, of course, an over-simplification. Rather it is that slowness of development becomes more rare as it becomes more pronounced, but extensive studies would show a few cases four and five sigmas above the mean age of development of the response. When the age distribution for the establishment of a response follows the normal distribution curve, we can apply the usual statistical concepts. We may say for instance that if our subjects fall more than 2.78 sigmas above the mean in age of appearance of any response the probability that we have produced an experimental effect is .997 in 1,000. In such cases we may be reasonably certain that the results are due to the experimental conditions rather than to chance selection of subjects.

Results

Reaching and Grasping a Visual Stimulus Reaching and grasping cannot be removed entirely from the influence of practice because the infant always has opportunities to reach his own extremities and to reach his bed and bed-clothes. Playing with the bed-clothes was discouraged as described earlier, but it did occur to some extent, and the infants of course played with their own hands They also grasped their feet and occasionally the experimenter's hand as he administered a stimulus This grasping may have been either visual or non-visual and it is unfortunate that we did not investigate its nature However that may be, our tests show a retardation in reaching for a dangling ring A dangling ring was presented once per day for forty days beginning with day 245 On each trial it was held above but within easy reach of the infant. The duration of each trial was 30 seconds. The child lay on her back in the crib Gesell's norms show that at six months (180 days) 65% to 84% of infants grasp a dangling ring. According to Shirley (8), the calipers used in her tests were reached for by 100% of her subjects at 154 days and grasped by 92% at that age. While further norms are desirable, we feel fairly certain that with normal experience our subjects would have reached for a dangling ring long before day 245. Yet Rey never reached for the ring until the 13th presentation and Del not until the 16th presentation. While the ring was fixated at every trial no attempts whatsoever at reaching occurred until the trials named above. In the case of each baby the first reaching had the appearance of developing out of some other activity. On Rey's first reach her hands came toward the ring with her fists *closed,* her left fist touched the ring, it then opened, pursued and grasped the ring and brought it to her mouth On Del's first attempt, her hands came toward the ring *clasped together* Her clasped hands touched the ring. Thereupon they unclasped, her right hand pursued the ring which had been set in motion by the contact, grasped it, and brought it to her mouth. Del reached and grasped the ring fairly accurately and quickly with her right hand in 20 successive trials following her first success. In the last three tests she paid little attention to the ring and did not reach. Rey, after her success on the 13th trial made no attempt to reach again until the 19th, when she grasped the ring directly

with her right hand and did not move her left, which had brought the first sucess. On the twentieth trial she missed once with her right and then succeeded in the second reach with her right. She attained the ring readily in each of 20 consecutive trials thereafter, using her hands without preference I must conclude that the early failures were due to the deprivation of practice However, the speedy establishment of reaching when once it was attempted is worthy of note. The fact that the ring was pursued when it moved indicates that the reaching was visually controlled.

Sitting Alone Sitting alone means the unaided maintenance of a sitting position when placed in it by the experimenter and *when passive balance is slightly disturbed.* It is important that this italicized phrase be included. A child who stiffens his spine when placed sitting may remain upright several seconds merely through passive balance. Very likely it is this kind of sitting alone, rather than real balancing, which is occasionally present in the newborn (7, 1) There is as yet no reason to believe that real sitting is ever present at birth.

The most extensive norms for sitting alone are those of M C. Jones (4). She recorded whether or not her subjects could sit alone for one minute. We are interested only in the upper age limits of this ability. Jones tested 28 children between days 270-289; of these only two failed to pass the test. Of 21 cases beyond day 290, every one succeeded.

In Shirley's group (8) of 25 children, the upper range for sitting alone was the 35th week (245-252 days) and among seven biographical studies analyzed by her it was the 39th week (272-280 days) Gesell (5) states that sitting alone is almost universal among normal children at 9 months (270 days) Linfert and Hierholzer (6) found that all of their subjects sat alone at nine months.

Regardless of the lack of a common precise definition, the studies agree very well in showing that practically every child can sit alone at about 270 days of age.

On day 263 Rey was placed in the sitting position on a pad on the floor (her legs about 60 degrees apart). When she inclined slightly backward or to either side, she made not the least observable effort to balance herself but fell toward the floor. (Naturally I caught her before she hit the floor unless the tumble was a very gentle one) This result was confirmed many times on that day.

However, when she fell *forward* her face was permitted to rest on the floor and she pushed herself upward with the arms and remained supporting herself with her arms in a frog-like posture. At the end of three minutes I picked her up. Subsequent tests confirmed the finding that she could support herself in this manner but in no other

I was at first astonished as I had not expected that sitting, even though present, would be accomplished in this fashion, and my first impression was that the response was a totally new one. (None of the normative studies mention this response but since the completion of the experiment I have seen photographs of other children in this posture) A little reflection, however, showed that pushing the head and chest upward from the floor with the arms was a well-practiced reaction. She had been tested many times for the "chest-up" response (8), and she had been placed prone on several occasions for exercise because we saw no relationship between such practice and the responses which we wished subsequently to test. The performance on day 263 seems therefore to be the transfer of a learned response to a slightly new situation, the only difference between chest-up and "frog-sitting" being that the legs were behind the trunk in the former and under the trunk in the latter. That this action can hardly be called true sitting is shown by the fact that in it the body was inclined far forward, and that when Rey was placed sitting fully erect she exhibited no tendency to balance herself. Although she was tested almost daily from day 263 onward, Rey first sat for a few seconds with no support from her arms on day 326, a date far beyond the upper age range for this act in other children. By the end of the first year she could sit alone for many minutes.

Del showed a similar course of development. Tested on day 262 she fell to either side, backward, or forward as did Rey. When first permitted to lie with her face on the floor she did not push with her arms but cried instead On a second trial a little later in the day she pushed herself upward slightly but started crying after 3 seconds and was picked up. Her improvement in sitting was gradual, but she sat for 20 seconds without arm support on day 298. I conclude that neither subject came within the age range of non-experimental or control subjects, and hence that the retardation of the subjects was attributable to the experiment. Needless

to say the retardation was only transitory, and the twins soon sat as well as any child.

Standing with Support. Standing with support or supporting the body weight on the feet means that the infant supports his entire weight when balanced by an external agency (usually by being grasped under the arms by the experimenter) and that this stiffening of his legs is really dependent upon his upright position and upon the contact of his feet with a surface. The latter clause is included because some might think it foolish to ask whether post-natal practice is essential to support of body weight since standing with support is sometimes reported in the newborn (1, 7). I am inclined to believe that the so-called standing of the newborn, as well as the "stepping movements" of the newborn, have little relation to the infant's position or to the surface with which he is in contact They may be mere "strong leg extension" and "alternating leg movements"[4]

In our tests I grasped the infant in the region of the armpits and maintained the child erect, brought her feet slowly to the floor, and let her sink to the floor if she did not support her entire weight. A partial support of the body-weight by the child could be felt by me as a lessening of the burden in my hands Gesell (5) finds that this test brings forth a pushing reaction of the feet in 85-100% of the cases at four months, although full support of the body is rarely achieved at that time Linfert and Hierholzer (6) find full support present in 10%, 92% and 100% at 6, 9, and 12 months respectively. (Fifty infants were tested at each age level by Gesell and by Linfert and Hierholzer.) The latest age for this performance in the 25 infants studied by Shirley was 37 weeks

Our subjects were tested for standing 20 times in the fourth month While there was a slight push with the legs in about one-fourth of the tests, it was momentary and never resulted in supporting the entire weight of the child Extensor thrusts may have occurred just as often when the child lay on her back although unfortunately we did not investigate that possibility Such tests were again given each subject on day 364 The results of the first of the delayed tests were essentially the same as those obtained

[4]Somewhat fuller comments on this point will be found in the proceedings of the first meeting of the Society for Research in Child Development, Nov, 1934

eight months earlier. In the first ten tests, neither baby supported her own weight. Del gave a slight push in all ten tests, Rey in only four. The pushes were of a momentary character which caused the infant to bounce up and down but not to stand Neither infant steadily supported her weight for even a fraction of a second.

A few minutes after the first tests on day 364 ten tests of a slightly different sort were given each subject. The infant was held as before except that I inclined each subject's head and chest far forward. This was done in order to determine whether there was any tendency for the child to bring her body into an upright position at the moment the leg extension occurred. The tests showed no such tendency.

In order to find how rapidly the infants would learn to stand with support, many trials (with the trunk upright) were given during the remainder of day 364 and on days 365, 366, and 367. No motivation for standing was given unless it be said that the pressure of the body upon the folded legs when the weight was not supported served as a motive The first momentary support of the body occurred on day 364 for each subject, only about eight hours after the first failure. When the length of the support grew to a measurable interval the duration of support on each trial was noted by a stop watch. Figures 1 and 2 show the progress beyond

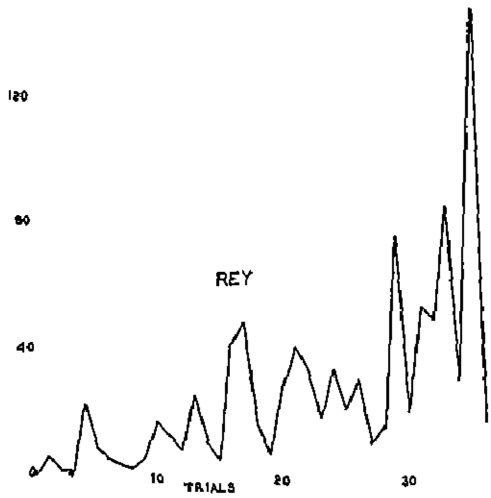

FIGURE 1

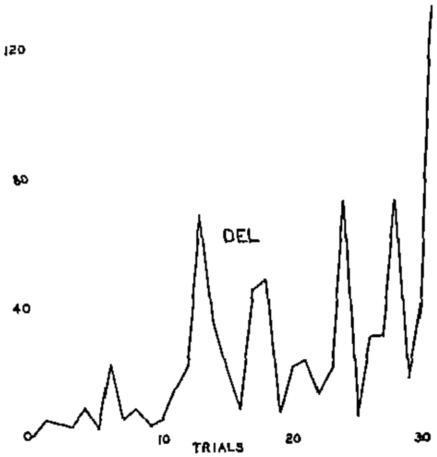

FIGURE 2

that point. The improvement in standing shown in the graphs was gradual and irregular, but before the close of day 367 each infant had stood continuously for two minutes or longer. I must interpret standing as I did sitting, that is, the experimental conditions retarded the occurrence of the initial performance, although this retardation was soon overcome

Subsequent Locomotor Development. Shortly after the tests just described, the infants became able to achieve the sitting position in their cribs of their own accord. (Unfortunately there are no norms on this performance, but it seems likely that the twins were retarded in this respect also Rey, day 387, Del, day 423) Once they were able to raise themselves to a sitting position, they could grasp the top of the cribs, make attempts to pull themselves to standing, and could also obtain practice toward standing by pushing against the sides of the cribs with their hands while stiffening their legs. To our minds it was impossible to prevent this practice without somehow forcibly restraining the babies. This we were not willing to do, so that the interesting question of the effect of restriction upon later activities remains unanswered Moreover, except for the act of walking alone, no comparative data were available for later responses in case the experiment had been prolonged.

With respect to walking alone, Rey achieved this response in the 17th calendar month, Del not until the 26th. Rey's record is

quite ordinary. Del's, while exceptional, is equalled by some children who are even urged and encouraged to walk. These facts do not indicate that our experiment *affected* walking, although greater deprivations might very well affect it.

Discussion

Evidence has just been presented to show that both of the twins were retarded in their establishment of visually directed reaching and grasping, sitting alone, and standing with support. Further, it has been shown that when training was instituted reaching and standing were established with relative promptness; sitting alone developed more slowly.

The explanation of these facts which I favor is that the retardation was due to the lack of the usual learning situations. Maturation alone, however it be defined, was insufficient

Other possible interpretations will no doubt suggest themselves and must be considered. The suggestion which I have received most often in relating the experiment orally is that the infants were improperly exercised and hence too weak to perform the required responses although the neural patterns were present. This suggestion has never been made by anyone who saw the twins in action. As a matter of fact the infants received a great deal of exercise. While it is true that prior to certain dates the infants did not exercise in the sitting position, in the standing position, etc, they were, like all infants, almost continuously active. A time-sampling study of crib behavior was conducted from days 185 to 240. The observational periods were 15 seconds in length and each infant was observed a total of approximately 1200 such periods when awake soon after a feeding. This study will be reported in full later but it may be helpful here to reveal that there were, on the average, approximately 3.5 *kinds* of movements per 15-second period per baby. The infants were in the best of health, were not rachitic, and their muscles were large and firm. Nevertheless, it may be suggested that while they were muscularly strong in many respects, yet the muscles involved in the performances which were tested were undeveloped. Two facts speak against any view which attributes the retardation of the infants to weakness of particular muscles rather than to the absence of proper innervation of these muscles.

The first is that observation of the infants in the early test trials did not reveal any attempts to perform responses which they were unable from weakness to carry through, as a child who has been ill may attempt to perform an action which he is too weak to accomplish Secondly, grasping and standing were established in a very short time There is no reason to believe that muscular strength may be developed with such speed. Rather it would be expected that much effort within a short period of time would fatigue the muscles.

Another possible interpretation of the retardation is that habits contradictory to the expected responses had been set up. So far as I could observe, the infants performed no response in the initial sitting tests except that of supporting themselves with their arms, and none in the first standing tests except for momentary extensor thrusts Neither these responses nor the responses to the dangling ring seem incompatible with the response whose presence was being tested

One must consider also the possibility that the reactions which we studied, although instinctive, waned of disuse before the proper tests were made. I am not aware that the phenomenon of the waning of an instinct has ever been demonstrated, so that one scarcely knows what is being considered under this title Each of the responses which has been examined was tested shortly before or after the expiration of the usual upper age extreme If the instincts waned, they must have done so in short order But even if the infants had been tested daily (which, by providing practice, would have defeated the purpose of the experiment) it might be urged that the instinct ripened and waned from lack of practice between two tests Until some evidence of waning is advanced, there is no reason to put much faith in this very flexible hypothesis.

That the infants were retarded by organic motor disabilities is contra-indicated by the fact that they learned readily to sit and to stand and to reach when training was begun. In fine, all other possible interpretations seem ruled out and it seems necessary to conclude that the twins were retarded in sitting alone, standing with support, and reaching and grasping because of the restriction of learning opportunities.

While a report of intelligence will be reserved until the twins reach an age at which tests have more significance than they possess

for the three-year-old, I may say that from present indications the children are not far from the American white average in test performance. However, there is little to indicate that reactions during the first year bear any relation to intelligence as tested at four or five.

Summary

Fraternal twins were reared with full experimental control under the personal care of Mrs. Dennis and myself from the end of the first to the end of the fourteenth calendar months of life. The choice of twins as subjects of the experiment was more or less accidental and was not essential to the problem. We imposed restrictions upon the infants' activities which consisted in part of keeping the infants on their backs in their cribs and consequently cut off from opportunities to sit and stand. Opportunities to reach for objects were reduced to a minimum. None of these restrictions was continued throughout the entire period of the experiment, but only until it was shown to have had some effect. The chief results of this study may be summarized as follows: visually directed reaching and grasping, sitting alone, and standing with help, were retarded in our subjects beyond the upper age limit for the appearance of each of these responses among children in the usual range of American environments. While other explanations of the retardations were sought, the only acceptable one was that the retardations were the result of restriction of activities Each response was readily established when practice was offered, and each response was "perfected" without social encouragement or approval.

The results are interpreted as showing that for some infants practice is essential in order that the responses under discussion be established in accordance with available norms

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L'EFFET DE L'EXERCICE LIMITÉ SUR L'ACTION DE TENDRE LA MAIN, DE S'ASSEIOR, ET DE SE TENIR DEBOUT DE DEUX ENFANTS

(Résumé)

On a élevé des jumeaux fraternels avec un plein contrôle expérimental sous les soins personnels de Mme Dennis et de moi-même depuis la fin du premier mois de la vie jusqu'à la fin du quatorzième. Nous avons assujetti les activités des enfants à des restrictions qui se sont composées en partie de faire rester les enfants sur le dos dans leur lit en les empêchant ainsi de s'asseoir et de se tenir debout. Les occasions de tendre la main vers des objets ont été réduites au minimum. Aucune de ces restrictions n'a été continuée pendant toute la durée de l'expérience, mais seulement jusqu'à ce que quelque effet s'était montré. On peut résumer ainsi les principaux résultats de cette étude: les actions visuellement dirigées de tendre la main et de saisir, de s'asseoir seul, de se tenir debout sans aide, ont été retardées chez nos sujets au delà de la limite supérieure de l'âge pour l'apparence de chacune de ces réponses parmi des enfants dans la variation usuelle des milieux américains. Tandis que l'on a cherché d'autres explications des retardations, la seule acceptable a été que les retardations ont été le résultat de la restriction des activités. Chaque réponse a été facilement établie quand on a offert de l'exercice, et chaque réponse a été "perfectionnée" sans encouragement ni approbation sociales.

DENNIS

DIE WIRKUNG DER BESCHRÄNKTEN ÜBUNG AUF DAS GREIFEN, SITZEN UND STEHEN VON ZWEI KLEINEN KINDERN

(Referat)

Brüderliche Zwillinge wurden mit voller experimentellen Kontrolle unter der persönlichen Pflege von Frau Dennis und mir vom Ende des ersten bis zum vierzehnten Monat des Lebens auferzogen. Wir legten Beschränkunken auf die Tätigkeit der Kinder, welche zum Teil aus dem Behalten der Kinder auf dem Rücken in ihrem Kinderbett bestanden. Dadurch wurden ihnen die Gelegenheiten zum Sitzen und Stehen entnom-

men. *Die Gelegenheiten zum Ergreifen von Gegenstanden wurde auf ein Minimum reduziert.* Keine dieser Beschrankungen wurde durch die ganze Zeit des Experiments hindurch gebraucht, aber nur bis es nachgewiesen wurde, dass sie irgend eine Wirkung hatte. Die Hauptergebnisse dieser Untersuchung konnen so zusammengefasst werden: visuell gerichtetes Greifen und Ergreifen, das Alleinesitzen, das Stehen mit Hilfe wurden in *unseren Vpn. bis über die obere Altersgrenze fur die Erscheinung jeder* dieser Reaktionen unter normalen Kindern in der amerikanischen Umgebung verzogert. Wahrend andere Erklarungen der Verzogerung gesucht wurden, war die einzige annehmbare, dass die Verzogerungen die Folge der Beschrankung der Tatikkeiten sei. Jede Reaktion wurde leicht festgesetzt, *wenn Übung gegeben wurde, und jede Reaktion hat sich zur* "Vervollkommung" ohne soziale Aufmunterung oder sozialen Beifall entwickelt.

DENNIS

SEXUAL DRIVE IN POTENT AND IMPOTENT MALE RATS AS MEASURED BY THE COLUMBIA OBSTRUCTION APPARATUS[1]

From the Department of Psychology, Stanford University

C. P. STONE, R. G. BARKER, AND M. I. TOMILIN

The primary aim of this study was to determine the importance of the factors *potency* and *impotency* on the performances of young male rats as they were tested for strength of sexual drive in the Columbia Obstruction Apparatus.

ANIMALS

The young males were reared under identical conditions of husbandry in the psychological laboratory at Stanford University. Beginning with the age of 35 days, they were tested on alternate nights for copulatory activity with receptive females (4); when positive results from these tests were obtained the males were set aside with other young males in storage cages to await the time of further experiments. They did not have access to females while in storage cages.

When the present experiments were begun, slightly less than half of the males had copulated during the copulation tests; these are called the *potent* males. The others, although similarly tested, did not copulate, hence they will be designated as the *impotent* group. It is to be understood, however, that the terms potent and impotent imply nothing more than that some males copulated and some did not, under what we regarded as adequate and comparable test situations.

In Table 1 are given the ages and body weights of the males at the time of testing and also their ages at the time of first copulation. The mean ages of the two groups did not differ significantly, but there was a significant difference in their ages at the time of first

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TABLE 1

GROUPS OF ANIMALS TESTED

	Potent males				Impotent males		
Animal No	Age at testing	Age first copulation	Weight at testing	Animal No.	Age at testing	Age first copulation	Weight at testing
1	67	36	166	25	63	65	164
2	68	42	174	26	63	76	150
3	68	39	189	27	64	*	113
4	67	39	206	28	66	68	186
5	64	38	190	29	66	68	175
6	68	38	194	30	60	77	196
7	65	44	180	31	58	71	216
8	69	39	219	32	58	*	173
9	68	53	176	33	68	77	124
10	68	37	203	34	65	89	162
11	62	62	166	35	65	72	150
12	67	53	221	36	62	82	154
13	65	42	193	37	66	79	123
14	68	37	176	38	66	77	180
15	66	43	205	39	82	140	164
16	65	65	171	40	67	82	162
17	66	42	190	41	65	69	126
18	64	59	155	42	66	92	156
19	67	57	160	43	54	58	152
20	66	65	155	44	66	92	144
21	69	39	243	45	64	79	144
22	65	43	180	46	66	74	136
23	69	39	207	47	57	71	182
24	69	38	209	48	63	88	144
				49	62	63	165
				50	65	90	159
				51	66	67	160
				52	65	92	182
				53	66	91	156
				54	67	65	169
				55	66	65	156
Mean	66 67	45.37	188 67		64 42	78 69	158 81
σ	1 72	9.45	21 96		4 55	15 06	21 75

*Numbers 27 and 32 were not observed to copulate in any of the tests.

copulation and also a difference in their body weights As shown at the bottom of Table 1, copulation was first observed in the potent group 33 days earlier, on the average, than in the impotent group, and the average weight of the potent group at the time of testing was 30 grams heavier than that of the latter group The difference in weights of these same groups is one of long standing. At the age of 45 days they differed, on the average, by 15 grams. Hence the

present difference cannot be ascribed to slight discrepancies in the ages at which they were tested in the Obstruction Apparatus.

In view of the fact that both groups of males appeared to be healthy and at no time to have suffered illness or malnutrition, we are inclined to ascribe the late sexual maturing of most of the impotent group, possibly all of them as well as a few of the potent group, to genetic factors which tend to retard the age of sexual maturity in certain strains of rats that have been selectively bred in the Stanford Laboratory. To date, there is no evidence bearing upon the supposition that late maturity that is genetically determined may be associated with relatively weak sexual drive as measured by copulatory tests or by the Obstruction Apparatus.

The Obstruction Tests

The model of the Columbia Obstruction Apparatus used in this experiment was illustrated in our previous paper dealing with sexual drive (5). Using a 110-volt, A. C. current of 60 cycles to electrify the grid, we set the inductorium so as to yield a terminal pressure of 730 volts. The external resistance in the circuit was 13,000,000 ohms, and the current flowing through the grid was .05615 milliamperes. This current was somewhat weaker than that used in our previous study (5) on adult males, but it appeared to produce about the same jump, startle, or withdrawal behavior in the young as the stronger current produced in the adult males. However, the means of equating faradic shocks in rats of different ages is still an unsolved problem.

Before the males underwent their tests in the Obstruction Apparatus, certain opportunities for preliminary experience were provided them. Approximately six hours before the test began, each animal was taken directly from its home cage, put into the Obstruction Apparatus, and allowed to explore the chambers for a period of 30 minutes without any special incentive present. A two-way door was at the juncture of the grid and the incentive chamber so that the male might become familiar with the process of going under the light celluloid door at this point.

As further preparation for the obstruction test, each male was given a brief copulation test with a receptive female in its home cage a few minutes before it was taken to the Obstruction Apparatus

which was operated in an adjacent room. The purpose of this was to activate the male sexually so that it would immediately attempt to copulate when the female was brought into its presence in the Obstruction Apparatus In the case of non-copulators, the female was allowed to remain with the male in the home cage for approximately 10 minutes, a period of time that permitted the male to sniff and to examine the female thoroughly and, in the majority of instances, one that finally ended with his directing his attention away from the female. A male that copulated was permitted only three or four intromissions, after which the female was removed from his home cage.

Immediately after sexual activation in the home cage, each young male was put into the Obstruction Apparatus where he was allowed complete freedom for exploration for a period of ten minutes. Because of the two-way door he could go back and forth between the starting and the incentive chambers without difficulty. At the end of ten minutes the experimenter replaced the two-way door between the grid and the incentive chamber by a one-way door The sexually receptive female was then put into the incentive chamber with the male. In the case of non-copulators, she was allowed to remain there for five minutes; but in the case of copulating males she was removed after three or four copulations

Next came the preliminary trials. The male was transferred by the experimenter to the starting chamber, from which only by crossing the grid and passing under the one-way door could he reach the female. Four preliminary crossings *without* shock and one *with* shock were given before the standard test period was begun. After the first preliminary crossing the male was allowed two minutes to copulate or to explore the incentive chamber (according to the direction of his activity), but only one minute was allowed for these activities after each of the other preliminary trials, after which he was transferred to the starting chamber The majority of the potent males immediately directed their activities to the female, but the impotent males, for the most part, seemed more attracted by other stimuli of the incentive chamber, such, for instance, as the one-way door which they attempted to push aside or to destroy by biting. If on the fifth preliminary trial the male failed to cross the grid voluntarily within five minutes, he was put into the grid chamber

by the experimenter and thus required to cross the electrified grid.[2]

The standard obstruction test consisted of two subtests of ten minutes each, separated by a five-minute interval. During each of the ten-minute tests the young males were allowed complete freedom to cross over the electrified grid to the incentive chamber but were returned to the starting compartment upon their arrival so as to preclude copulation with the receptive female. Now and then, however, a male was too quick for the experimenter and copulated before he could be removed. In rare instances also an intromission was accompanied by an ejaculation which made it necessary to halt the experiment until the male again had become sexually aggressive toward the female. In the interim between the ten-minute tests the receptive female was left in the incentive chamber with the male for what may be called the second sexual activation period. Impotent males were allowed to remain with the female for three minutes, potent males for a similar length of time unless before the end of three minutes they had copulated three of four times; in which case they were removed lest a long pause be necessitated by their becoming sexually inactive from delivering vaginal plugs. The males spent the remaining two minutes of the intermission in a small home cage placed beside the table on which the Obstruction Apparatus was resting.

Results of the Experiment

The principal data on which our discussion will hinge and from which conclusions will be drawn are given in Tables 2, 3, and 4.

1. *Results of the Activation and Preliminary Tests.* In the first four columns of Tables 2 and 3 the outcome of all copulation tests given the males in the home cages, during the preliminary trials in the apparatus, and during the intermission between the subtests of the experiment proper, are indicated by the plus or minus signs. Each plus or minus sign of column 5 indicates whether or not a male crossed the grid voluntarily on the fifth trial of the preliminary period, that being the first in which the grid was electrified.

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[2]As a general procedure, this technique is of questionable value for it may enhance the male's fear of the grid chamber beyond that already caused by the punishment grid and also may set up an antagonistic attitude toward the experimenter. We shall discontinue it in future experiments and try, by additional trials without shock, to induce the male to begin crossing the grid.

TABLE 2

PRELIMINARY SEX BEHAVIOR, GRID CROSSINGS AND GRID CONTACTS BY THE POTENT MALES

In columns 2, 3, 4, and 5, respectively, are indicated by plus or minus signs whether the males copulated in their home cages, in their preliminary tests with the apparatus, in the interim between the subtests, and whether they crossed the grid voluntarily on their fifth preliminary trials The last three columns give, respectively, the number of grid crossings, grid contacts, and the sums of crossings and contacts

	Preliminary tests					Test proper		
Animal	Copulation in home cage	Copulation in prelim	Copulation in interval	Voluntary crossing, trial 5		Crossings	Contacts	Crossings plus contacts
1	+	+	+	+		85	30	115
2	+	+	+	+		0	7	7
3	+	+	+	+		50	12	62
4	+	+	−	−		0	0	0
5	+	+	+	+		6	27	33
6	+	−	−	−		0	2	2
7	+	+	+	+		82	17	99
8	+	+	+	−		0	5	5
9	+	+	+	+		93	23	116
10	+	−	+	−		1	11	12
11	+	+	+	+		30	19	49
12	+	−	−	−		0	1	1
13	+	+	+	+		71	32	103
14	+	+	+	+		24	18	42
15	+	+	+	+		41	15	56
16	+	+	+	+		54	16	70
17	+	+	+	−		2	20	22
18	+	+	+	+		41	42	83
19	+	−	−	−		0	0	0
20	+	+	+	+		151	31	182
21	+	+	+	+		53	7	60
22	+	+	+	+		84	16	100
23	+	+	+	+		66	22	88
24	+	−	+	−		0	17	17
					Mean	38 92	16 25	55 17
					σ	40 11	10 89	42 23

Upon examining columns 1 to 4, one observes that the males that copulated in their home cages, with but few exceptions, also copulated in the Obstruction Apparatus. This result is what we hoped to obtain, inasmuch as it indicates that sexual drive was dominant over exploratory drive, over fear, and over other conflicting types

TABLE 3

PRELIMINARY SEX BEHAVIOR, GRID CROSSINGS AND GRID CONTACTS BY THE IMPOTENT MALES

In columns 2, 3, 4, and 5, respectively, are indicated by plus or minus signs whether the males copulated in their home cages, in their preliminary tests with the apparatus, in the interim between the subtests, and whether they crossed the grid voluntarily on their fifth preliminary trials The last three columns give, respectively, the number of grid crossings, grid contacts, and the sums of crossings and contacts

	Preliminary tests				Test proper		
Animal	Copulation in home cage	Copulation in prelim	Copulation in interval	Voluntary crossing, trial 5	Crossings	Contacts	Crossings plus contacts
25	—	—	—	—	3	15	18
26	—	—	—	+	38	1	39
27	—	—	—	—	0	0	0
28	—	—	—	+	1	9	10
29	—	—	—	+	20	21	41
30	—	—	—	+	11	2	13
31	—	—	—	+	18	5	23
32	—	—	—	—	0	12	12
33	—	—	—	+	5	2	7
34	—	—	—	—	0	0	0
35	—	—	—	+	0	3	3
36	—	—	—	+	12	4	16
37	—	—	—	+	11	10	21
38	—	—	—	—	11	12	23
39	—	—	—	—	0	7	7
40	—	—	—	—	0	1	1
41	—	—	—	—	0	7	7
42	—	—	—	+	39	3	42
43	—	—	—	—	0	6	6
44	—	—	—	+	23	9	32
45	—	—	—	—	0	8	8
46	—	—	—	+	19	7	26
47	—	—	—	—	0	4	4
48	—	—	—	—	1	3	4
49	—	—	—	—	0	7	7
50	—	—	—	—	0	1	1
51	—	—	—	+	28	9	37
52	—	—	—	+	0	7	7
53	—	—	—	+	6	6	12
54	—	—	—	—	0	2	2
55	—	—	—	—	0	2	2
				Mean	7 93	5 97	13 90
				σ	5 37	5.06	14 00

TABLE 4

POTENT MALES

Number of contacts and crossings of the grid made by each rat during each minute of the total test. A five-minute recess was interspersed between trials 10 and 11, thus dividing the total test into two subtests of 10 minutes each

		SUCCESSIVE MINUTES OF TEST																			
Rat No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Co Cr	13 2	6 2	2 1	3 1	1 1	1 3	6	2	2		2 4	9	1 7	6	1 7	8	4	3	9	8
2	Co Cr	4						2					1								
3	Co Cr	2 5	1 6	3 1	3	1 1	2	6	3	3	3	4	1 3	1	2	6	2	1	2	1	1 1
4	Co Cr																				
5	Co Cr	12 2	2	1						1		2	2					2	4 1	1	1 2
6	Co Cr	2																			
7	Co Cr	5 3	2 6	2 4	4	4	3	2 2	1 2	2	2 3	1 6	5	3	4	4	1 4 2	5	6	6	1 7
8	Co Cr	1		1				1													
9	Co Cr	1 7	3 6	3 5	5 5	6	2 4	1 3	1 3	2 3	4	7 6	2 5 3	4	5	5	1 4	1 5	1 5 2 1	3	8
10	Co Cr																				
11	Co Cr	4 3	8									4 2 1	6	4	5	1 2	2	1 3	3		1
12	Co Cr																				
13	Co Cr	3 5	4 5	5 2	3 3	3 2	2 2	4 2	3 1	2 1	3	8	6	2 4	1 4	4	4	4	5	3	3
14	Co Cr	2 2	2 1	1	5		2				1	1 4	5	5	4	3	3				
15	Co Cr	2	2						4 1	2 4	2	1 2	4	4	1 4	3	1	1 3	2 4	5	4
16	Co Cr	7 4	3 1	1			3	1				1 1	4	8	8	7	3	5	6	4	3
17	Co Cr	3						2	4 1	5 1			1	5							
18	Co Cr	14			2	1 1	10	6 3	6 4	1 6	3	7	9	2	1 2	2	2	2	3	1	1
19	Co Cr																				
20	Co Cr	13 1	3 1	2 7	1 8	2 8	8	10	1 8	7	7	11	11	9	1 10	2 7	7	9	8	8	5 6
21	Co Cr	1 4	1 5	3	2 2	2	9	1 1	2	2	4	4	3	3	3	1 3	1 2	2	1	2	2
22	Co Cr	6	1 2	1 4	3	2 3	1 2	3	3 2	4	4	8	5	2 2	3	7	2 3	5	8	4 5	6
23	Co Cr	10 2	2 1	4 2	3	1 8	2 3	4	1 2	1 1	2	5	1 5	5	5	3	2	2	5	5	3
24	Co Cr	6	1	1	3	1						1	1						3		
Mean	Co	4.4	1.7	1.1	1.0	0.5	1.0	0.8	1.1	0.6	0.1	0.8	0.5	0.4	0.2	0.2	0.4	0.2	0.5	0.2	0.4
Mean	Cr	1.9	1.5	1.2	1.3	1.4	1.3	1.7	1.2	1.5	1.5	3.0	3.1	2.5	2.7	2.6	1.8	2.1	2.6	2.2	2.1

TABLE 4 (*Continued*)

IMPOTENT MALES

SUCCESSIVE MINUTES OF TEST

Rat No		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
25	Co	4					1	3				1						4	2		
	Cr	1						1										1			
26	Co	1																			
	Cr	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	1
27	Co																				
	Cr																				
28	Co	3	1										1		1	1			1	1	
	Cr																1				
29	Co	3		4	1	4	3	1			1				1	2					
	Cr	1			1	1		2	1	2	1	2	1	1	1	1	1	1	1	1	1
30	Co								1	1	1								1		
	Cr	1	1			1	1	2				1	1	1	1						
31	Co	2	1	1					1												
	Cr	1	1	2	2	1	1	2	1			2					1	2	1	1	
32	Co	1		2				1			2	1						2			3
	Cr																				
33	Co									1						1	1	1			
	Cr																				
34	Co																				
	Cr																				
35	Co	1			1																
	Cr																				
36	Co	4																			
	Cr	2		1								2	1	2	2						
37	Co	3	1								1	2	1	1	1						
	Cr	1	1							1			1		2	1	1	1		1	1
38	Co								3			2	2	1	2	1			1		
	Cr												1	1	2	1	1	1	1	1	2
39	Co	1					2							1	1	2					
	Cr																				
40	Co	1																			
	Cr																				
41	Co	2		1	2	2															
	Cr																				
42	Co	1	1																		
	Cr	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
43	Co	2							1			1	1							1	
	Cr																				
44	Co	1	2	3	2					1											
	Cr	1	2	1	2	1	1	1	1	2	1	1	2	1	1		1	1	1	2	
45	Co		3								1	1					3				
	Cr																				
46	Co	4	2			1															
	Cr	1	2	1			1	2	1	2	1	1	1			1	1	2	1	1	
47	Co	1														4					
	Cr																				
48	Co											1							1	1	
	Cr																		1		
49	Co	2	1											1	2	1					
	Cr																				
50	Co									1											
	Cr																				
51	Co	4		1				1	1		1	1									
	Cr	2	1	2	1	2	1	1	1	2	1	1	1	1	2	1	2	1	1	2	2
52	Co	2						3	1	1											
	Cr																				
53	Co	2			3				1												
	Cr	1			1	1			1	1		1									
54	Co	2																			
	Cr																				
55	Co										1	1									
	Cr																				
Mean	Co	1 5	0.4	0.4	0.3	0.2	0 2	0 3	0 3	0 2	0 3	0 4	0 2	0 1	0 3	0 4	0.1	0.2	0.2	0 1	0 1
Mean	Cr	0 6	0 4	0.4	0 4	0.4	0 3	0.5	0 3	0.5	0 3	0 5	0 4	0 4	0 5	0.3	0 4	0 4	0.4	0 4	0.3

of *motivation.* We should not have expected males to copulate in the Obstruction Apparatus if, on this and on previous nights, they had failed to copulate in the more familiar home-cage situation where distracting stimuli were relatively few in number

As shown in column 5 of Tables 2 and 3, the proportion of voluntary crossings was clearly greater for the potent than for the impotent group

2. *Differences in Crossings and Contacts.* At the bases of the last three columns of Tables 2 and 3 are given the means and sigmas for the total number of crossings, contacts, and sums of crossings and contacts. In each case the mean of the potent group is significantly greater than that of the impotent group, the $\frac{\text{Diff.}}{\sigma_{diff}}$ being, respectively, 3.5, 4.6, and 4.6. These differences warrant the conclusion that copulating males of the ages herein studied are, *as a group,* much more aggressive and persistent than non-copulating males in their efforts to overcome a painful obstruction to reach the sexually receptive female

In Table 4 is recorded the number of crossings and contacts made by each animal in the successive minutes of the test. At the bases of the columns the mean numbers of crossings and contacts are given These means are presented graphically in Figure 1.

In the case of the potent males, there was a declining frequency of crossings from the beginning to the end of the second subtests

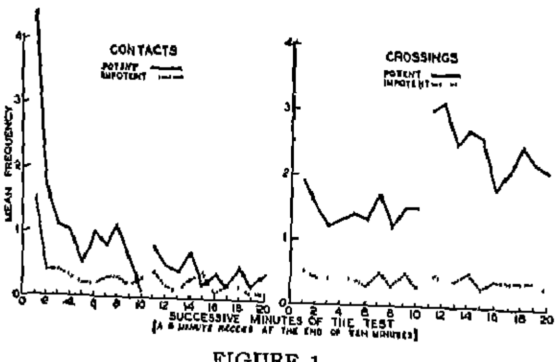

FIGURE 1
MEAN NUMBER OF CONTACTS AND CROSSINGS OF THE GRID IN THE OBSTRUCTION APPARATUS MADE BY THE GROUPS OF POTENT AND IMPOTENT MALES.

This, possibly, may be ascribed to the animals' becoming negatively conditioned against the punishment grid or the experimenter, or possibly to a radical change in physiological state resulting from being repeatedly shocked and thwarted in their efforts to copulate with the female. No crucial evidence on the point of causation is available, however

As shown in Figure 1, the potent group crossed much less frequently, on the average, during the first than during the second half of the test, but for the impotent group there was but little difference. This result strongly suggests that the sexual ardor of some of the potent males was greatly strengthened by the opportunity for copulation in the incentive chamber during the intermission

The outstanding feature of the contact records is the drop in frequency after the first minute This may have resulted primarily from the fact that weakly motivated males quickly learned to stay away from the grid, whereas more highly motivated males plunged right ahead or learned to jump to the farther side, effecting thus a crossing rather than a contacting of the grid.

Great individual differences in performance within each of the groups are apparent in Table 4. Numbers 4 and 19, although copulating males, neither crossed nor contacted the grid during the test proper; numbers 2, 6, 8, and 24 failed to cross the grid although they made one or more attempts during the test proper and thus experienced the painful shock It is very probable that more thorough preliminary training without the shock would have started some of these males to crossing and, once a beginning had been made, some of them probably would have continued throughout the test as did most of the other potent males This is only an hypothesis, however, that we shall have to investigate in future experiments with potent, non-crossing males

Number 20 crossed the grid with a frequency that closely approximated the maximal number possible under the conditions of this experiment in which two sliding doors had to be opened and shut each time the male was transferred from the incentive chamber to the starting compartment Numbers 11 and 14 crossed over at the beginning of each test but became inactive before the end. Numbers 7 and 9 were steady performers throughout the entire test Numbers 1, 11, and 16 are of interest because they became much more active crossers in the second than in the first half of the test. As to the cause of these differences in performance one can only guess.

Although one is forcefully impressed by the greater incidence of non-crossers and low-frequency crossers within the impotent group, there are a few individuals, such as numbers 26, 42, and 51, whose records would not appear markedly out of place if put among those of the potent males These cases clearly demonstrate that the presence or absence of copulating ability and sexual experience are not the only factors that determine whether or not a male will cross the grid in the Obstruction Apparatus. While working with impotent males the experimenter (Tomilin) received an impression from observing their total behavior throughout the test that the crossings of many were prompted far less by the receptive female than by some adventitious factor such as the one-way door which they attempted to manipulate as they had formerly manipulated the two-way door. This situation reveals the desirability of having some independent indicator of the male's sexual agitation by means of which each instance of crossing can be attributed either to sexual or to non-sexual motivation

3. *Methodological Implications of the Present Study.* It is pertinent to inquire as to whether there is any likelihood that the present trend of results with young males would also be found in the case of adult males In answer to this inquiry we may say that the only known evidence directly applicable indicates that the trend of results would be the same. Data on adult albino rats collected by Anderson (1), who with great fidelity followed the specifications set forth for the Columbia Obstruction Method (6), show an average of 3.4 crossings for 10 impotent males and 11.7 crossings for 40 potent individuals, all of which had been similarly handled prior to the obstruction test. Assuming that more extensive investigations would confirm the results of the present as well as Anderson's study, one may then legitimately stress the point that the present data have a very significant bearing upon the interpretation of some of the data published by the Columbia University workers (6).

It appears that Warner (7) used only copulating males when setting up the masculine norms used by himself and his successors Jenkins (2) and Nissen (3) How many non-copulators Warner had to discard from the lot obtained from the Wistar Institute was not reported, but if the males were fundamentally similar to those used by his successors, as was desired (6), one might assume that the loss was well over 50 per cent because Jenkins found 58 non-

copulators in a group of 79 males and Nissen found 15 non-copulators in a group of 27 males At any rate Warner's data pertain to a selected group of males and, according to the trend of the present data, and those of Anderson as well, the Warner norms were unsuitable standards for use by Jenkins and Nissen who had an admixture of potent and impotent males. Moreover, there seems to have been no systematic distribution, either by Jenkins (2) or by Nissen (3), of copulators and non-copulators when making up their various experimental groups Since their groups were relatively small (twenty individuals or less), a random selection would not assure a satisfactory balancing of the two types of animals. In consequence of this and the use of Warner's norms one cannot determine with assurance in which instances or to what extent the specific results obtained are to be ascribed to the experimental regimens to which a group was subjected rather than to the original constitution of the group itself. In some instances the obtained differences are probably too small, in others, too large; and in still others they may be spurious in the sense of not arising from the specific variables under consideration Thus, if our contention is correct, the full significance of the data on the male rats reported by Jenkins and by Nissen cannot be ascertained until these experiments have been repeated with due consideration to the factor of potency and impotency in control and experimental groups

To Jenkins and Nissen it may have seemed unnecessary to take account of the factor of potency and impotency in their experiments in view of unpublished findings (3) accredited to Warner which, in effect, showed that frequency of copulations was not correlated with frequency of crossing the grid However, the true import of Warner's finding cannot be ascertained in view of the fact that he reports that his primary intention was not to obtain an accurate record of the exact number of copulations performed by the males of his group but, rather, to ascertain whether or not they were sexually active Inaccuracies of recording copulations might easily account for the zero correlation Also, what was true for Warner's group of copulators might not have been true either for the data of Jenkins or those of Nissen in which there were non-copulators as well as copulators Finally, we may call attention to the fact that Anderson obtained a correlation of .509± 072 between the frequency of copulations in direct tests and the frequency of crossings in the

obstruction test. The present authors, using the Columbia Obstruction Apparatus, but not following the prescribed method, obtained a correlation of .32±.105 for copulations and crossings, and .40±.099 for copulations and the sums of contacts and crossings (*r*'s uncorrected for attenuation). Each of these studies supports the present contention that the factors of potency and impotency must be carefully controlled in studies of sexual drive that are carried out with the Columbia Obstruction Apparatus on male rats if interpretable results are to be obtained.

Summary

1. In this study a significantly greater mean number of crossings and contacts of the grid of the Columbia Obstruction Apparatus was made by a group of 24 potent male rats to reach a receptive female in the incentive chamber than was made by a comparable group of 31 impotent males.

2. From these results it appears that the factors of potency and impotency should be taken into account in all studies of sexual drive involving male rats. The data on males reported by Jenkins and Nissen, who used the Columbia Obstruction Method, are somewhat equivocal because they failed to control these factors in forming their original groups and, in certain instances, in choosing a strictly comparable norm with which to evaluate the results from their experimental groups.

3. Great individual differences in willingness to cross and contact the grid were obtained within groups. The two distributions of scores overlap to such an extent that one must conclude that neither copulatory experience nor the lack of it was a certain basis for predicting whether a particular male would cross the grid in the test as herein conducted.

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L'IMPULSION SEXUELLE CHEZ LES RATS MÂLES CAPABLES ET INCAPABLES SEXUELLEMENT MESURÉE PAR L'APPAREIL DES OBSTACLES DE COLUMBIA

(Résumé)

On a fait cette étude dans le but de determiner l'importance des facteurs, *capacité sexuelle*, c'est-à-dire, capacité copulatrice et *l'incapacité sexuelle*, dans l'exécution des jeunes rats, comme on les a testés dans l'Appareil des Obstacles de Columbia pour la force de l'impulsion sexuelle. Il y a eu 24 mâles dans le groupe capable, et 31 mâles dans le groupe incapable En considérant les groupes comme ensemble, un nombre moyen significativement plus grand de traversements et de contracts du gril a été fait par les mâles capables que par les incapables Cependent, de grandes différences individuelles se sont montrées dans chaque groups En effet, les distributions s'empiètent à un tel degré qu'on ne pourrait considerer ni la capacité copulatrice ni l'incapacité comme base certain pour prédire si un certain mâle serait ou ne serait pas celui qui traverserait fréquemment le gril dans la situation du test

D'après la différence des moyennes des deux groupes contrastés, il paraît qu'on devrait toujours rendre compte des facteurs de capacité et d'incapacité dans les études de l'impulsion sexuelle où il s'agit du rat mâle et que les résultats des expériences antérieures sur l'impulsion chez les rats mâles, comme testée par la Technique des Obstacles de Columbia, sont un peu équivoques pour l'interprétation parce que les facteurs capacité et incapacité n'ont pas été suffisamment contrôlés

STONE, BARKER, ET TOMLIN

DER SEXUELLE TRIEB BEI SEXUELL KRAFTIGEN UND UNKRAFTIGEN MANNLICHEN RATTEN, WIE SIE DURCH DEN COLUMBIA HINDERNISAPPARAT UNTERSUCHT WURDEN

(Referat)

Der Zweck dieser *Untersuchung war die Bestimmung der Wichtigkeit der Faktoren von Potenz*, d.h. Paarungsfahigkeit, und Impotenz in der Leistung junger weisser Ratten, wie sie im Columbia Hindernisapparat untersucht wurden, der die Starke des Sexualtriebes ermittelte. Es gaben 24 mannliche Ratten in der Paarungsfahigen Gruppe und 31 Mannliche Ratten in der Paarungsunfahigen Gruppe. Im grossen und ganzen gabe es *eine bedeutsam grossere Anzahl der Übergehen und Berührungen mit dem* Gitter bei den paarungsfahigen als bei den paarungsunfahigen Mannchen. Es fanden sich aber grosse Unterschiede in jeder Gruppe. In der Tat greifen sie so sehr ubereinander, dass man weder die Paarungsfahigkeit noch deren Mangel als eine sichere Basis zum Voraussagen ansehen konnte, ob ein besonderes Mannchen viel oder wenig uber das Gitter in *der Testsituation laufen würde*.

Aus dem Unterschied der Durchschnitte der beiden Gruppen scheint es, dass die Faktoren der Potenz und Impotenz in Untersuchungen des Sexualtriebes bei der mannlichen Ratte immer in Betracht gezogen werden mussen und dass die Ergebnisse der fruheren Experimente uber den Trieb bei mannlichen Ratten, wie er durch die Columbia Hindernismethode untersucht wurde, *etwas zweideutig zur Deutung seien*, weil die Faktoren der Potenz und Impotenz nicht hinreichend kontrolliert waren.

STONE, BARKER, UND TOMILIN

THE INFLUENCE OF AMOUNT OF INCENTIVE ON DELAYED RESPONSE PERFORMANCES OF CHIMPANZEES*

From the Laboratories of Comparative Psychobiology, Yale University

H. W. Nissen and J H Elder

Since 1907, when Yerkes (8) drew attention to the importance, in studies of animal learning, of quantitative control of motivational factors, a considerable amount of work on this general topic has been reported These studies have concerned themselves with the quantitative aspects of both the initiating drive (degree of hunger, thirst, and sexual need, temperature of the heated or cooled floor, amount of electric shock) and of the incentive factor which tends to restore physiological balance (amount of food, water, sexual satisfaction and so on) In many instances the interest has been merely in the relative effects of presence or absence of one of these factors In this connection should be mentioned also those investigations, notably the series of Columbia studies (7), which combine qualitative and quantitative comparisons by relating the maximum scores obtained under various drive-incentive conditions.

Indices of differential motivating factors have been obtained by the obstruction, choice, activity, learning, and work methods The performance or work method[1] measures the speed, frequency, intensity, or accuracy of an innate response or previously mastered habit —speed of eating, frequency of copulation, amount of muscular effort, accuracy and speed of running a previously learned maze. Measurements of delayed response performances under different motivating conditions belong here or under a sub-category. the mental work method

The present paper deals with the effects, general and specific, of quantitative variations of the food incentive on delayed response performances of four young chimpanzees Incidentally, the constancy

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[1]We would place under this heading the "present or absent," the "frequency" and the "satiation" methods of Stone (6)

of delay limits[2] under uniform conditions, the effects of practice and of the number of trials given in succession, are considered. Grindley's study (4) appears to be the only comparable previous investigation concerned with the influence of varying amounts of food reward when the total reward was actually ingested; in the experiments of Bayer (1) the total amount of food available varied but was always in excess of the animal's capacity The only earlier study (5) in which delayed response has been used to measure the relative effectiveness of various incentives dealt with the influence of qualitative differences in the incentive on performance at certain constant delay intervals, whereas in the following pages we shall be concerned with quantitative differences as affecting both performance at certain levels of difficulty and limits of delay.

Subjects

Four pre-adolescent chimpanzees, three males and one female, all members of the New Haven experimental colony of the Yale Laboratories of Comparative Psychobiology, were used in the experiment. The following list gives the name, sex, numerical designation, approximate weight, and estimated age at the time of experimentation, and dates of work with each subject:

Name	Sex	Number	Approx. weight	Estimated age	Dates of work
Bokar	Male	5	39 kgms	8 yrs.	July, 1932 to May, 1933
Moos	Male	11	27 kgms.	7 yrs.	April to July, 1934
Kambi	Female	24	20 kgms	5 yrs.	February to June, 1934
Velt	Male	31	19 kgms	5 yrs.	April to June, 1934

The animals were apparently in good health throughout the periods of work, except that Velt had a habit of regurgitating his food, which interfered to an appreciable extent with experimentation

[2]Throughout this paper we shall speak of "delay limits" and of "maximum delays" as meaning merely the longest delays at which the animals would perform with an accuracy of 80 per cent or better under the conditions of the experiment One of the conclusions of this study is that such "limits" are extremely flexible and variable, depending doubtless on almost every aspect of the experimental situation.

Apparatus and Procedure

The apparatus and details of procedure employed differed for the several animals, but were rigidly constant for each subject with the exception of the variables being studied. Since the comparisons made in this paper are not between individuals but rather between the performances of a given individual under different conditions, such diversity is unobjectionable and even desirable; any consistent trend in the results is thereby shown to be a function of the experimental variables and independent of the particular techniques employed. Only the more essential features of each of the three forms of delayed response apparatus used will be described.

1. For Bokar a modification of the turntable apparatus, originally devised by Yerkes (9) for use with the gorilla, Congo, was employed. In its present form a circular wooden disc, 4 cm. thick and 183 cm. in diameter, revolving in a horizontal plane, is mounted in front of the barred opening of the subject's cage at a distance which permits the animal to reach about 20 cm. beyond the circumference of the disc. Centered on a diameter of the turntable are two wooden boxes without bottoms, 18 cm. long, 16 cm. wide and 10 cm. high; they are fastened to the table by means of hinges on the side towards the center of the disc and so located that the centrifugal edge of each box is approximately 4 cm. from the circumference. Under each of the two boxes an aluminum cup, in which the lure was placed, is fastened directly to the turntable. A projecting ledge on the outer end of each box makes it possible to raise the box, disclosing the cup underneath.

The restraining cage used with the turntable apparatus is approximately 180 cm. square, 184 cm. high, inside dimensions. The top is constructed of wire mesh, the sides of pine planking. On one side is a solid entrance door; on the opposite side are two openings protected by horizontal iron bars 10 cm. apart. Each of these openings or windows, one directly above the other, is 60 cm. wide; the first, starting a few centimeters above the floor, is 60 cm. high, while the second, 9 cm. above the top of the first, is 46 cm. high. A line drawn from the center of the turntable to the center of the lower window would be perpendicular to the front side of the cage. Each window affords a view of the entire turntable. By reaching through the lower grille the animal can rotate the table and, when the proper position has been reached, open one of the boxes and so obtain the

food in the cup. Either one or both of the two barred windows can be closed by the experimenter by means of two opaque doors sliding in horizontal tracks fastened to the outside of the cage.

The standard procedure is as follows: Both doors to the two windows are closed The turntable is adjusted so that the diameter drawn through the two boxes is exactly parallel to the side of the cage through which the animal works. Both boxes are closed. The door covering the upper window is pulled back and the experimenter goes to whichever side is to be the positive one on that trial As soon as the animal is at the grille and watching, the experimenter opens the box, drops the food into the cup, closes the box, and finally closes the door over the grille After the proper delay interval has elapsed the experimenter, out of view of the animal, pulls open first the top and then the lower door As soon as the lower door is opened the animal reaches out, grasps the edge of the turntable and turns it in one direction or the other. Having turned 90 degrees, the chimpanzee opens the box and reaches into the cup, whether or not he finds food there depends on the correctness of his choice Both doors are closed; the table is brought back into position and, if the last response was wrong, the food is taken out of the cup not selected. The next trial follows immediately.

2 For Moos and Velt a pull-in apparatus was employed. The restraining cage is one built by Dr. T. A. Jackson; it is 183 cm. long, 100 cm. wide, and 200 cm. high. In one of the short sides is a barred opening, 84 cm. square, extending upward from the floor level, through which the animal works Facing this opening and resting on the floor is a platform, 84 cm. wide, 210 cm. long. At the far end of the platform is a vertical screen, 97 cm. wide, 180 cm high. Into this screen, 50 cm. above the platform, an opening, 25 x 87 cm., is cut, covered by a hinged door Somewhat higher is a square opening covered by copper screening painted white on the outside and affording one-way vision. Centered on the platform are two lengths of wood, approximately 1 5 cm square, in the shape of a T The shorter arm of this T, 84 cm. long, is parallel to the working side of the cage. The longer arm, 220 cm., projects through the center of the bottom of the screen. On the platform also are two food boxes, 10 x 10 x 12 cm., having neither top nor back side. A cord attached to the front of each box is fastened at the other end to a point 16 cm to either side of the center of the shorter arm of the

T A second cord, fastened to the back of each box, extends through a small hole in the screen.

The following procedure was employed with this apparatus. By means of ropes passing over pulleys the experimenter, located behind the screen, raises a wooden door covering the barred opening of the cage. Reaching through the hinged door in the screen, he drops a piece of food into one or the other of the two boxes, located on the platform directly in front of the screen. The T has previously been drawn back, so that the two cords attached to the shorter arm are out of reach of the animal By means of a rope, the door to the cage is then closed At the end of the delay interval it is opened and at the same time the T is pushed forward, bringing the two cords within easy reach of the animal, who responds by pulling on one or the other Ordinarily only one box is pulled in, in the few instances of vacillation and alternate pulling on one and the other, whichever box first reached a point half-way to the grille was considered the animal's "choice," since beyond this point it is possible for the subject to look into the box and see whether or not it contains food After response, the T is pulled back some 50 cm and the boxes are drawn back to the screen At the same time the door over the barred opening is closed A few seconds later the next trial is started.

3 For Kambi a delayed response apparatus originally designed by us to test the effect of the number of alternatives for selection, and of the distance between them, was used. The restraining cage is 110x80 cm and 78 cm. high, its floor is formed by a table top, the ceiling and three sides by wire mesh One of the long sides is covered by vertical bars, 7½ cm. center to center. Facing this side is a second table, 110x80 cm On this table is a board 94x24 cm on which the two food boxes, each 10x10x12 cm., are mounted. The distance between these two boxes, center to center, is 25 cm The top and front side (one piece) of each box is hinged to the back, so that the animal can open it easily, when the lid is closed (by gravity) it is impossible to see whether or not the box contains food By means of an iron rod attached to the back of the board, the two boxes can be drawn to the back of the table, out of reach of the animal, or pushed forward to the barred side of the restraining cage. A raised frame around the edges of the table keeps the board with the attached food boxes always exactly parallel to the front edge of

the table. A screen, 36x102 cm., made of Upson board and containing a one-way vision mirror (Argus glass, obtained from Semon Bache and Co., New York City), is so hinged to vertical supports at the ends of the table that it can be lowered in front of the food boxes during the delay, or in back of the boxes while they are being baited and during the response. The experimenter is seated behind the far side of the table and is visible to the animal only while the boxes are being baited and for a brief moment before response as the board with the two boxes is pushed forward towards the restraining cage.

The procedure employed with this apparatus was as follows: The boxes being in the far position, and the screen swung to its position behind them, the experimenter opens one of the boxes and places the food inside, the lid of the box then falls into the closed position and the screen is turned forwards so that it entirely obscures the view (by the animal) of the two boxes. At the end of the delay interval the screen is raised, the board with the two boxes is pushed forwards, and the screen is lowered behind the boxes. The animal, reaching through the grille, opens one of the boxes and, if his response has been correct, takes the food. The boxes are then immediately pulled back again, food is removed (in case response was incorrect), and the next trial is begun.

Certain features of procedure were common to all four subjects of the experiment. In order to obtain "delay limits," the length of the delay intervals was increased gradually according to a system similar to one used and discussed by us in a previous paper (2). Except in the "mixed series," described in the next section, the delay was constant for a series, that is, for all trials given in succession during one experimental period.[3] When the score (percentage correct) on a series dropped to 75 per cent or less, the delay interval used in that series was repeated in the next series. If the score now increased to 80 per cent or better, a longer delay was used in the following test series. If, on the other hand, repetition of a given delay interval resulted in an even lower score, it was arbitrarily assumed that a delay limit had been reached. The only exception

[3]One exception. In Group 1, Table 1 (Bokar) three different delay intervals were used in every series, a five-second delay on every second trial, separating trials with the two longer intervals (which were increased from series to series).

made to this rule was when some distinctly unusual circumstance (e.g., distraction) was the obvious cause of the low score, in which case another series at the same delay was given. A number of series in which the degree of difficulty gradually increased until a "limit" was reached is here called a test group. Within a group, the amount of incentive per trial and the number of trials per series remained constant.

As far as possible, all factors except the experimental variables were kept constant from one test group to the next. Special attention was directed to the following: (*a*) Time of day and feeding at mealtimes. (*b*) Interval elapsing between successive trials of the same series. (*c*) Movements of the experimenter and time taken for baiting, that is, time during which the animal gets his cue for the next response. (*d*) Distractions and all stimuli which might lead to an abnormally favorable or unfavorable emotional response. (*e*) The quality of banana used as incentive was kept as constant as possible, care being taken that it contained no blemishes and that it was neither too green nor over-ripe. The banana was cut into slices; the indicated weights include the skin which was usually eaten. For Bokar and Moos both small and large incentives consisted of a single piece, for Kambi and Velt the larger rewards consisted of two or four 5-gram pieces.

Results and Discussion

Test trials were not begun with any animal until the subject had reached a certain level of performance with a short delay, about five seconds, the minimum possible with the methods used. The required motor response was mastered rapidly in all cases; following this, preliminary delayed response trials were begun. The amount of such preliminary training necessary to attain the required degree of accuracy varied considerably from individual to individual. For Bokar this training period covered 28 days during which 458 trials were given, at the end of this time his scores were 90 or 100 per cent. It should be noted that Bokar was a relatively "unsophisticated" animal, that is, he had been used previously in only one other experimental study. Moos, an animal with much experience in laboratory work, responded almost perfectly on the first day, his training preliminary to the test series reported in the following tables consisted of 20 successive trials. Kambi, whose earlier experience in

laboratory experiments was somewhat less than that of Moos, was given 40 preliminary trials distributed over four days. Velt, for whom the present study meant initiation to laboratory work, was started on the apparatus used with Kambi; he did not adapt well and was transferred to the pull-in apparatus after six days. There he was given 120 trials on 13 days. On four of these days he refused to work at all; apparently he was at first afraid of the solid door which closed the grille during delay intervals.

Tables 1, 2, 3, and 4 show results for four animals in the main experiment; in Figure 1 these data are presented graphically. The chronological sequence of the tests may be followed by reading down in the column marked "Test group I," then going to the next column and so on. Except for the final series in some of the groups, and as otherwise noted in the tables, the scores as given indicate the percentage of correct responses for one series of trials given in succession during one experimental period. The number of trials in a series is shown at the top of the column. When several scores are entered for one delay interval, it indicates that a corresponding number of series were given at that point, in accordance with the systematic procedure of increasing delays outlined above. The symbol "E" means that the animal manifested an emotional upset which precluded, in the opinion of the experimenter, the possibility of proceeding to longer delay intervals. Such emotional disturbances found expression in a variety of forms: hesitation in responding, refusal to watch the baiting, whimpering, screaming, and even temper tantrums; they gave supplementary evidence that a delay limit had been reached. The notation "Ind" is entered when the animal, during the last series of a group, manifested indifference and lack of attention rather than an emotional outburst. Apparent indifference to the baiting was not always an indication that the maximum delay had been attained, since certain animals, especially Kambi and Moos, often seemed to make a point of being "casual" in their attitude, giving merely a fleeting glance over the shoulder as banana was being placed in one or the other box. We feel, however, that such "nonchalance" could be differentiated from the more antagonistic attitude appearing with long delays, and have made the notation "Ind" only in the latter cases. A plus sign, on the other hand, indicates that the animal was still working well at the maximum delay employed and probably would have worked satisfactorily at longer intervals. An italicized number within a column indicates the point

TABLE 1

BOKAR

Showing percentage correct responses with varying number of trials per series, length and sequence of delay intervals, and amounts of reward

Test group	I	II	III	IV	V	VI
No. trials per series	30*	20	10	10	5**	5
Amount of banana per trial	12 gms	12 gms	12 gms	60 gms	60 gms	12 gms
Delay						
5 sec	96	100				
10	100	95	100	90		
15	93	100	100	100		
20	93	100	100	100		
25		100	100	100		
30	*100*	100	90	90		
40			100	90		
45	93	75-70-85				
50			90	100		
60	100	80-95†	70-100	90		100
70				100		
75			90			100
80				100		
90	74	*90*	70-90	→	100	100
100					100	
105			60-60			100
110			E		100	
120	50	75-50-40			90	100
135		E			100	
150					80	*80-40†*
165					80	E
180					100	
210					100	
240					90	
300					100	
360					80	
420					100	
540					100	
720					100	
900					100	
					+	

*Score for 5 sec based on 113 trials, for 90 sec on 23 trials, for 120 sec. on 14 trials, and for all other intervals on 15 trials See footnote, p 54

**Two series of five trials given at each delay interval, each score based on 10 trials

†Series at 150 sec repeated because of indication, at end of first series, of an emotional upset

TABLE 2

Moos

Showing percentage correct responses with varying number of trials per series, delay intervals and amounts of reward.

Test group	I	II	III	IV	V	VI
No trials per series	20	10	20	10	10	10
Amount of banana per trial	6 gms	6 gms.	3 gms.	3 gms.	12 gms	3 gms
Delay						
5 sec.	85					
10	90					
15	90					
20	90	70-90	90	50-100	100	90
25	65-70 85	90	95	100	90	90
30	75-100	100	95	80	100	100
40	65-90	100	85	100	100	100
60	75-80	100	90	90	100	100
90	75-85	100	65-75-85	50	100	100
120	80	100	47	E	90	100
150		70-50	E			25
180	65-60	Ind			80	E
240	E				100	
300					80	
					+	

below which a score of 80 per cent or better was not attained; the data indicate that these "limits" are rather definite and that further trials, under the conditions specified, would not have changed them Our records of qualitative aspects of the animals' behavior strongly support this conclusion.

The Effect of Practice and Number of Trials per Series. As was indicated above, the initial adjustment of the animals to the experimental situation manifested itself as a more or less gradual improvement in accuracy of performance This improvement was especially pronounced in the less "sophisticated" subjects, whose initial scores were not far from a chance level. Once a certain degree of proficiency had been reached, however, the factor of practice isolated from other influences apparently had no appreciable or consistent effect either on the scores at a given delay interval or on the limits of delay We would draw attention particularly to the records of Bokar (Groups I, II, III), of Moos (Groups I and II, III and IV), of Kambi (Groups I and II, III and IV, VI and VII), and of Velt (Groups I, II, III). In only two cases does the repetition of a

TABLE 3

KAMBI

Showing percentage correct responses with varying delay intervals and amounts of reward

Test group	I	II	III	IV	V	VI	VII	VIII	IX
No trials per series	10	10	10	10	10	10	10	10	10
Amount of banana per trial	*5* gms	*5* gms	*10* gms	*10* gms	*20* gms	*5* gms	*5* gms	*20* gms	*5* gms.
Delay									
5 sec.	80								
10	80	60-100		100					
20	60-80	100	90	60-100		100	90		90
30	*50-80*	*90*	60-100	100	100	100	100		100
40	60-70-50	60-70-50	80	70-90	100	70-90	100		100
60	Ind	Ind	*80*	100	100	80	*100*	90	90
75			*60-60-40*	*80*	*90*	*90*	*70-70-60*	*100*	*80*
90			E	30	100	80	Ind	100	90
120			Ind	50-90		100		70-70-90	90
180					90	80		90	*70-90*
240					90	*80*		90	60-70-60
300					100	50		90	
480					+			100	
720								100	
1200								100	
								+	

TABLE 4

VELT

Showing percentage correct responses with varying delay intervals and amounts of reward

Test group	I	II	III	IV
No trials per series	10	10	10	10
Amount of banana per trial	5 gms.	5 gms	5 gms.	20 gms
Delay				
5 sec	100			
10	90			80
20	70-90	90	100	90
30	100	60-60-100	90	90
40	100	*50-80*	*80*	70-80
60	100	50	50-60	90
75	*100*	Ind.	Ind.	90
90	60-70-50			80
180	Ind			90
240				90 +

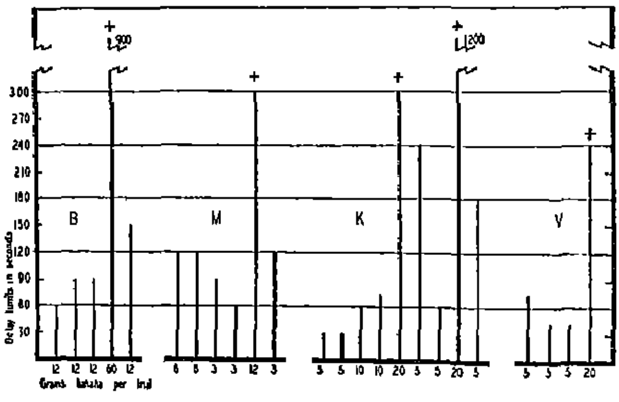

FIGURE 1

DELAY LIMITS ATTAINED IN SUCCESSIVE TEST GROUPS, WITH VARYING AMOUNTS OF INCENTIVE, BY EACH OF THE FOUR SUBJECTS

Chronological sequence from left to right A plus sign indicates that the animal was still performing with an accuracy of 80% or higher when trials were discontinued B=Bokar; M=Moos, K=Kambi; V=Velt.

series with the same amount of reward per trial result in improvement in the limit, in one of these (Kambi) the change is slight, and in the other (Bokar) the particular distribution of delays within a series and the interval of time (over two months) separating Group I from the following two groups must be taken into consideration. Offsetting the two instances of increase with repetition, there are four cases in which no change takes place, and three cases which show a decrease with repetition These data certainly would suggest that mere practice, once the preliminary adaptation to the situation has been made, does not have any significant or consistent effect in raising the level of delayed response performance in chimpanzees.

In some of the test groups used for comparison above (Bokar and Moos) the number of trials per series varied, in each case decreasing with successive groups This fact would militate against the above conclusion only if it be assumed that a longer series is more favorable to accurate performance than is a short series of trials There would seem to be no reason for making such an assumption, on the contrary, one might expect that fatigue, lessened motivation, increasing strain or tension, and interference effects from preceding presentations and responses would tend to favor the shorter series [4] The following tabulation suggests that the number of trials per series, within the range employed (5 to 30 trials), is of relatively small importance in determining the delay limits obtained

		Delay limit on the second test group is		
		Higher	The same	Lower
When the length of the series	*Shorter*	1	2	1
in the second group is	*The same*	1	2	2

Our conclusions regarding the role of practice in delayed response on first thought seem to be in conflict with those of Foley and Warden (3) who conclude from their study that "There is no doubt but that the data show positive practice effects" Several important differences between the two studies must be taken into account when making comparisons of the results (1) In one, the subjects were monkeys, in the other, chimpanzees (2) Foley and Warden were interested in scores on certain delay intervals whereas we are primarily concerned with delay limits (3) As was mentioned above, our conclusions regarding practice effects apply to animals who have passed through a preliminary adaptation period dur-

[4] See also section below Analysis of errors

ing which there was definite improvement in performance. It is quite possible, even probable, that Foley and Warden's monkeys were still in what we have called the preliminary stage of adaptation when tested, in which case there would be no discrepancy between the results of the two studies. The fact that on the first 10-minute delay the monkeys made scores very little better than chance supports this interpretation. (4) It will be pointed out below that the nature of previous experiences in delayed response, other than mere frequency of response, has a decided influence on later performance. A six-second delay, for instance, probably is not the same thing after 30 trials with a 40-second delay as it is after 30 trials with a three-second delay. The fact that 15-, 20-, 25-, 30-, and 40-second delays preceded the last 10-second delay tests may be a better explanation of the superiority in scores on this last group over the second group of 10-second tests than the fact that opportunity for practice was afforded in the meantime

The Effect of Increasing and Decreasing Amount of Reward per Trial. From Figure 1 and Tables 1, 2, 3, and 4 it may be seen that, without exception, increasing the quantity of lure used per trial raised the delay limits obtained (six instances), whereas decreasing the amount of reward (five cases) lowered the limits The number of cases is of course too small to warrant reliability computations, but the direction of change is consistent and the magnitude of the differences convincing. It is to be noted that in four instances the ultimate limits obtainable with the larger rewards were not determined, and also that the steps by which the delay intervals were increased became progressively greater; the differences therefore are even larger than superficial examination of the tables would indicate.

The exact quantitative relationship between size of reward and delay limits cannot be calculated from our data, first, because of lack of some of the limit determinations, and second, because of the fluctuations in such limits apparently produced by the phenomenon of perseverating incentive effects discussed below. In Table 5, however, these relationships, in so far as they are available in our data, are shown The relative increase in delay limit, it may be seen, is greater than the corresponding relative increase in the amount of reward used in five out of six cases; in one instance the two ratios are exactly the same. The relative reduction of delay limit is greater in two cases, smaller in two cases (and of uncertain relative magni-

TABLE 5

Showing (1) the maximum delays obtained per unit of reward (one gm of banana) with varying amounts of reward per trial and (2) the relation between increases (and reductions) in amount of incentive and corresponding delay limits

Animal	Test group	Gms banana per trial	Delay limits in sec	Sec delay per gm banana (at limit)	Relative increase in (1) amount of reward and (2) corresponding delay limit		Relative decrease in (1) amount of reward and (2) corresponding delay limit	
					Reward	Delay	Reward	Delay
Bokar	I	12	60	5 0				
	II	12	90	7 5				
	III	12	90	7 5				
	IV V	60	900+	15 0+	5	10+		
	VI	12	150	12 5			2	<.17
Moos	I	6	120	20 0				
	II	6	120	20 0				
	III	3	90	30 0			5	75
	IV	3	60	20 0				
	V	12	300+	25 0+	4	5+		
	VI	3	120	40 0			25	.4
Kambi	I	5	30	6 0				
	II	5	30	6 0				
	III	10	60	6 0	2	2		
	IV	10	75	7 5				
	V	20	300+	15 0+	2	4+		
	VI	5	240	48 0			25	<.8
	VII	5	60	12 0				
	VIII	20	1200+	60 0+	4	20+		
	IX	5	180	36 0			25	< 15
Velt	I	5	75	15 0				
	II	5	40	8 0				
	III	5	40	8 0				
	IV	20	240+	12 0+	4	6+		

tude in one instance) than the corresponding relative decrease in amount of reward. Another method by which the quantitative relationship between these experimental variables might be determined is that of calculating the maximum delay, in seconds, obtained for each gram of banana used, when the total amount of incentive differs in successive test groups In the fifth column of Table 5 we show this quotient, which may be appropriately termed the "ef-

ficiency index" of the incentive, for each test group of each of the subjects. Our data are too limited to permit any conclusions regarding the form of the curve (efficiency index plotted against total amount of incentive), but it may be seen that in general this index is higher for the large incentives than for the small, probably the expression of this tendency is obscured by the perseverative effects discussed below. Except for Kambi and Velt, the efficiency index of the incentive cannot be compared from one animal to another, since other factors, such as type of apparatus, absolute amount of incentive, and experimenter, were not the same In the case of Kambi and Velt all such factors were comparable

Perseverating Effects of the Incentive. Tables 1, 2, and 3 and Figure 1 show that, after an animal has successfully performed at long delay intervals under the condition of a large reward, his subsequent delay limit with a small reward will be higher than it had been previously. This is shown by Bokar (column VI), Moos (column VI), and by Kambi (columns VI and IX) There is some indication in the quantitative data, and more in our qualitative observations, that the effect of a small incentive also perseverates, attenuating the scores on subsequent trials with larger rewards The data suggest, furthermore, that this "after-effect" of the incentive (or of the performance induced by the incentive) is not permanent but instead wanes with time or with repeated trials. See especially Table 3, columns VI and VII.

There are at least two general types of explanation possible for this perseverative effect: (1) After working at long intervals of delay, shorter intervals may be relatively easier than they were before, by contrast they may "seem" shorter than before. (2) The "expectancy," "set," or "attitude" induced by the larger reward may persevere until, gradually, it is replaced by one which conforms to the new (smaller) incentive.

Mixed Series It appears from the preceding section that the incentive in delayed response has a fairly diffuse, generalized influence; the effect of large rewards, for instance, extends to performances occurring later in time. In order to determine whether there is, in addition to this general, perseverating effect, some specific influence on the response which directly follows the "baiting" or presentation of the incentive in association with one or the other food container, tests under the following special conditions were given three of the animals.

In the Group VI tests a delay limit of 150 seconds had been determined for Bokar when the incentive consisted of 12 gms of banana (From what has been said above it appears that this limit would have been somewhat lower, probably about 90 seconds, if testing had been continued) After completion of the Group VI tests, Bokar was given four days of 10 trials each (Table 6, Group *A*) with length of delay and amount of incentive varied in a simple

TABLE 6

MIXED SERIES Showing number correct responses with various combinations of short and long delays, small and large incentives.

(*a*) *Bokar* Maximum possible on each combination, 10 in Groups *A* and *C*, 5 in Group *B* Total number of trials 100.

Delay		Group *A* 150″	Group *A* 300″	Group *B* 180″	Group *B* 360″	Group *C* 300″	Group *C* 600″	Total No.	Total %
Incentive	12 gms	7	7	5	5	6	6	36	72
	60 gms	10	9	5	5	9	10	48	96

"Short" delay 42 correct, 84%
"Long" delay 42 correct, 84%

(*b*) *Moos* Maximum possible on each combination 10 Total number of trials 40

Delay		210″	420″	Total No	Total %
Incentive	3 gms	7	9	16	80
	24 gms	10	9	19	95

"Short" delay 17 correct, 85%
"Long" delay 18 correct, 90%

(*c*) *Kambi* Maximum possible on each combination 15 in Group *A*, 8 in Group *B* Total number of trials 92

Delay		Group *A* 360″	Group *A* 600″	Group *B* 360″	Group *B* 600″	Total No	Total %
Incentive	5 gms	11	11	8	7	37	80
	20 gms	14	12	8	8	42	91

"Short" delay 41 correct, 89%
"Long" delay 38 correct, 83%

alternation sequence from trial to trial according to a prearranged schedule. On the first day trials with a small reward (12 gms) and short delay (150 seconds) alternated with trials involving a large reward (60 gms) and long delay (300 seconds). On the next day

trials with large reward and short delay alternated with small reward, long delay trials. The schedule for the entire 10 days (100 trials) of the mixed series is given herewith; in each case the conditions for the first two trials only are given, the remaining eight trials being repetitions of this first pair.

1st day	(Trial 1)	small reward (12 gms),	short delay (150 seconds)
	(" 2)	large reward (60 "),	long delay (300 ")
2nd day	(Trial 1)	large	short
	(" 2)	small	long
3rd day	(Trial 1)	large	long
	(" 2)	small	short
4th day	(Trial 1)	small	long
	(" 2)	large	short
5th day	(Trial 1)	small reward (12 gms),	short delay (180 seconds)
	(" 2)	large reward (60 "),	long delay (300 ")
6th day	(Trial 1)	small	long
	(" 2)	large	short
7th day	(Trial 1)	large reward (60 gms),	short delay (300 seconds)
	(" 2)	small reward (12 "),	long delay (600 ")
8th day	(Trial 1)	large	long
	(" 2)	small	short
9th day	(Trial 1)	small	short
	(" 2)	large	long
10th day	(Trial 1)	small	long
	(" 2)	large	short

On the fifth and sixth days the "short" delay was increased to 180 seconds, the "long" delay to 360 seconds (Group *B*). Between Group *B* and Group *C*, Bokar was given four days of 10 trials each with a constant reward of 12 gms. and with increasing delays. Results for these four days are as follows.

1st day	Delay 180 seconds,	score 90 per cent correct
2nd day.	180	90
3rd day.	240	90
4th day.	300	20

The last four series of mixed trials (Group *C*, Table 6) accordingly were given with a short delay of 300 seconds and a long delay of 600 seconds. Following the last of the mixed series, 10 trials were given with 12 gms reward per trial and a delay of 300 seconds; the score was 70 per cent correct

Moos was given only four series, 10 trials each, of the mixed series. The schedule of alternations used corresponded to the 7th, 8th, 9th, and 10th days of Bokar's schedule; for Moos, however, the rewards were 3 gms. and 24 gms, the delay intervals 210 seconds and 420 seconds, respectively. It is to be noted that the short delay

is well above the maximum attained in Group VI (Table 2) when a 3-gm. reward was used on each trial Results are presented in Table 6.

For Kambi the incentives used in the mixed series weighed 5 gms. and 20 gms, respectively, the short delay was 360 seconds, the long delay 600 seconds Six series of 10 trials each (Group *A*) and four series of eight trials each (Group *B*) were given. The system of alternations in Group *A* corresponded to days 7, 8, 9, 10, 7, 8, in Group *B* to days 7, 8, 9, 10 of Bokar's schedule (see above) The shorter of the two delay intervals employed in the mixed series was *about twice as long as the maximum attained with a 5-gm. reward* in Group IX (Table 3) After completion of the Group *A* mixed series, Kambi was given 10 trials with a constant incentive of 5 gms. and a delay of 360 seconds; her score was 50 per cent correct. At the end of the Group *B* series, scores of 88 per cent, 100 per cent and 75 per cent were obtained on three successive days of eight trials each · 5 gms. reward, 360 seconds delay

Table 6 indicates (1) that, under the conditions of the mixed series, the amount of incentive which the animal sees being placed into the container during the presentation period is of significance[5] in determining the accuracy of the following response, (2) that under these conditions the length of the delay interval is relatively unimportant; *and (3) that interspersing large-reward trials* among the small-reward trials results in a better performance (greater accuracy) with small incentives than is possible when only small rewards are used This suggests, then, that the incentive in delayed response has both a general effect (as was also determined in the previous section) and an effect specific to the response following presentation (sight) of the incentive

Scores at Certain Delay Intervals under Varying Conditions With the exception of the section on mixed series we have emphasized, in this paper, the effects of the experimental variables on delay limits rather than on scores at given delay intervals The main

[5]Using the formula $\sigma_p = \sqrt{\frac{p\,q}{n}}$, and combining Groups *A*, *B* and *C*, *we find that the difference between Bokar's scores with small and large* rewards, respectively, is 3.5 times the S D of the difference Neither of the other differences are statistically reliable, but all are consistent in direction.

part of this experiment was planned to facilitate comparisons of the former kind rather than of performances at certain levels of difficulty. Consideration of the varying number of trials given in a series (errors increase towards the end of a series) and especially of the perseverative effect of the incentive, indicated above, makes it apparent that comparisons by the second method will not be unambiguous With this warning, we present, in Table 7, a summary recapitulation of the data, in which only scores on immediately suc-

TABLE 7

Showing relative magnitude of scores at the same delay intervals when the incentive (*a*) is the same, (*b*) increases, and (*c*) decreases in successive test groups

(*a*) Same amount of reward per trial

Test groups	Bokar II & III	Moos I & II	Moos III & IV	Kambi I & II	Kambi III & IV	Kambi VI & VII	Velt I & II	Velt II & III	Total number of instances
Scores the same	3	0	1	1	1	1	0	0	7
First score higher	3	1	2	0	1	1	2	0	10
Second score higher	1	6	2	2	2	2	1	3	19

(*b*) Increasing amount of reward

Test groups	Bokar III & IV, V	Moos IV & V	Kambi II & III	Kambi IV & V	Kambi VII & VIII	Velt III & IV	Total number of instances
Scores the same	4	1	0	2	0	1	8
Small reward scores higher	2	1	2	0	1	2	8
Large reward scores higher	3	3	0	2	0	0	8

(*c*) Decreasing amount of reward

Test groups	Bokar IV, V & VI	Moos II & III	Moos V & VI	Kambi V & VI	Kambi VIII & IX	Total number of instances
Scores the same	1	0	5	2	1	9
Small reward scores higher	2	2	1	1	1	7
Large reward scores higher	1	4	1	5	3	14

cessive test groups (adjacent columns in Tables 1-4) are compared. Where there are several scores at a certain level within the same group, these have been averaged. No scores appearing below the italicized numbers in Tables 1 to 4 inclusive were used in making up Table 7. Group I of Bokar's record is omitted because of the special conditions obtaining in these test series. The amount of difference between scores is not considered; the figures in the table show merely the number of cases for each direction of difference.

Analysis of Errors. In Table 8 is given a partial analysis of the errors made by the several animals in successive portions of the experiment. It is seen that some of the subjects had rather decided left-right preferences or tendencies, these animals seemed to be working on the principle When in doubt, take the right (or left) box. Of particular interest is the preponderance of errors during the last half, as contrasted with the first half, of each series. Table 8 has a total of 30 divisions in which the pertinent data are available (last three columns); in 20 of these the second half has more errors than the first half of the series, in two cases the numbers are equal. The significance of this finding is enhanced when considered in connection with the fact (see above) that the number of trials per series seems to have no effect on the scores or delay limits obtained. It is tempting to conclude that the animals anticipated or had a "set" for the length of the experimental period. A more detailed analysis of the distribution of errors, not presented here, shows that the number of incorrect responses does not increase with any regularity towards the end of the series, the error curve shows marked fluctuations.

Response Time. During all of Moos's trials and during the latter half of the trials given Kambi, the time elapsing between the moment when the animal first had opportunity to respond and actual initiation of overt response was measured with a stopwatch and recorded. Inspection of the records indicates a small positive correlation between average response time and number of errors in a series, within a series wrong responses have, on the average, slightly longer response times than have correct responses. The amount of incentive used in various test groups does not correlate with average response time.

SUMMARY

Four young chimpanzees were used in delayed response situations

TABLE 8

SHOWING NUMBER OF ERRORS MADE ON LEFT AND RIGHT SIDES, AND DURING THE FIRST AND SECOND HALF OF EACH SERIES OF TRIALS

	No of trials	Total errors	Errors on Left	Errors on Right	Errors in first half of series	Errors in second half of series	Errors last vs first half of series*
			Bokar				
Preliminary training	458	101	63	38	45	56	+
Group I	240	20	13	7	9	11	+
II	300	44	18	26	13	31	+
III	140	18	14	4	3	15	+
IV	100	4	2	2	3	1	—
V	160	8	5	3	3	5	+
VI	35	4	0	4	2	2	=
Mixed series	100	16	8	8	8	8	=
Total	1533	215	123	92	86	129	
			Moos				
Preliminary training	20	4	No record				
Group I	360	75	31	44	29	46	+
II	100	13	8	5	9	4	—
III	180	33	13	20	9	24	+
IV	70	8	5	3	3	5	+
V	100	6	1	5	4	2	—
VI	74	5	2	3	5	0	—
Mixed series	40	5	2	3	3	2	—
Total	944	149	62	83	62	83	
			Kambi				
Preliminary training	40	16	8	8	9	7	—
Group I	90	29	13	16	12	17	+
II	70	17	8	9	8	9	+
III	80	23	13	10	6	17	+
IV	90	17	6	11	9	8	—
V	100	9	1	8	1	8	+
VI	110	18	9	9	10	8	—
VII	70	11	6	5	4	7	+
VIII	120	11	7	4	3	8	+
IX	120	21	8	13	6	15	+
Mixed series	92	13	4	9	4	9	+
Total	982	185	83	102	72	113	
			Velt				
Preliminary training	120		Record incomplete				
Group I	110	17	13	4	7	10	+
II	70	21	18	3	8	13	+
III	50	12	10	2	4	8	+
IV	100	15	14	1	5	10	+
Total	450	65	55	10	24	41	
All animals	3209	614	323	287	244	366	

*A plus sign means that more errors were made during the last half of the series than during the first half, a minus sign indicates the reverse relationship, and an equal sign shows that the number of errors was the same in both halves.

for the purpose of determining the effect of quantitative variations of the food incentive on performance

The data show that an increase in amount of incentive used consistently increased the delay limits Decrease in amount of incentive always resulted in lower limits.

The amount of incentive affected not only response within a given trial, preceding ingestion of the reward, but produced also a general perseverative effect on subsequent responses, raising or lowering efficiency of performance according to the relative size of the incentive.

The "efficiency index" of the incentive, that is, the quantitative relation between amount of incentive and delay limits, is discussed.

After preliminary adaptation to the situation, mere practice did *not increase delay limits. The number of trials given in succession* likewise seemed to have no influence

More errors were made in the second half of each series than during the first half, regardless of the length of the series.

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L'INFLUENCE DE LA QUANTITÉ DU STIMULANT SUR LE RENDEMENT DES CHIMPANZÉS AVEC DES RÉPONSES RETARDÉES

(Résumé)

Dan cette étude il s'agit des effets généraux et spécifiques des variations quantitatives de la nourriture comme stimulant sur le rendement de quatre jeunes chimpanzés avec des réponses retardées.

En employant une quantité donnee de récompense, on a entrainé chaque sujet à choisir l'une de deux boîtes de nourriture dans laquelle il avait vu placer de la nourriture par l'expérimentateur. L'intervalle de temps entre la mise de nourriture dans la boîte et l'occasion de la réponse a été systématiquement augmenté jusqu'à ce que l'on avait atteint la limite de la retardation

Une augmentation de la quantité de la récompense a donné conséquemment comme résultat une augmentation de la durée où le sujet a pu répondre comme il faut. La décroissance de la quantité de la récompense a produit l'effet contraire

Outre l'effet sur l'exactitude de la réponse qui précède la vraie ingestion de la récompense, la quantité du stimulant produit un effet général de persévération sur les réponses subséquentes. Après qu'un animal aura montré un rendement réussi à de longs intervalles de retardation sous la condition d'une grande récompense, sa limite de retardation sera plus élevée qu'auparavant. On montre que les effets de l'exercise seuls ne peuvent expliquer cet effet. Quand on entremêle des épreuves à grande récompense avec des épreuves à petite récompense, on a comme résultat un meilleur rendement avec la petite récompense que l'on ne peut avoir quand la série se compose entièrement d'épreuves petite récompense

NISSEN ET ELDER

DER EINFLUSS DER MENGE DES ANSPORNES AUF DIE VERZÖGERTE REAKTIONSLEISTUNGEN BEI SCHIMPANSEN

(Referat)

Dieses Studium beschatigt sich mit den allgemeinen und besonderen Wirkungen der quantitativen Veranderungen des Futteranspornes auf die verzögerte Reaktionsleistungen von vier jungen Schimpansen.

Beim Gebrauch einer bestimmten Menge Futter als Belohnung wurde jedes Tier trainiert, einen von zwei Futterkasten zu wahlen, in den es den Vl. das Futter hineinstecken sah. Der Zeitraum zwischen der Ladung des Kastens und der Gelegenheit zur Reagierung wurde systematisch vergrössert, bis die Grenze der Verzogerung erreicht wurde

Die fortdaurende Vermehrung der Menge der Belohnung ergab eine Vermehrung der Zeitdauer, die bei jedem Tier zum richtigen Reagieren notig war. Die Verminderung der Belohnung hatte die entgegengesetzte Wirkung

Ausser dem Einfluss auf die Genauigkeit der Reaktion vor der eigentlichen Einnahme der Belohnung erzeugt die Menge des Anspornes eine allgemeine Beharrlichkeitswirkung auf nachfolgende Reaktionen. Nachdem das Tier die Leistung erfolgreich uber lange verzogerte Zeitabstande unter der Bedingung einer grossen Belohnung ausgefuhrt hat, wird seine Verzogerungsgrenze mit einer kleinen Belohnung hoher sein, als sie vorher war. Es zeigte sich, dass die Übungswirkungen allein diese Wirkung nicht erklaren konnen. Die Einmischung von grossen Belohnungen mit kleinen Belohnungen ergibt eine bessere Leistung mit der kleinen Belohnung, als es moglich ware, wenn die Reihe ganz aus kleinen Belohnungen bestünde

NISSEN UND ELDER

SECOND YEAR DEVELOPMENT OF A RHESUS MONKEY *(Macaca mulatta)* REARED IN ISOLATION DURING THE FIRST EIGHTEEN MONTHS*[1]

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JOHN P. FOLEY, JR

The present paper represents a continuation of a previously reported study of the development of the rhesus monkey *(Macaca mulatta)*, and deals with the second postnatal year, the first half of which was spent in continued isolation, and the second half in contact with other members of the colony The need for such naturalistic and observational studies of the development of various primate forms needs no verbal justification A detailed study of the ontogeny or developmental continuum of such an organism serves as an essential background for related investigations of a more experimentally controlled nature. The interpretation of the behavior of animals in various experimental or laboratory situations can be legitimately made only in terms of its larger genetic configuration or meaning—the reactional biography of the organism (cf 5, pp 39-41) Yerkes (41) has admirably stated the need for standardized primates, particularly of the anthropoid type, showing the many risks and disadvantages of using animals whose age or developmental status, sexual condition, disease history, and experience are unknown Nissen (24) has pointed out, for example, how many of Kohler's *Umwage* and instrumentation situations (20) might readily be explained in terms of behavior mechanisms acquired and frequently executed in the natural habitat of the chimpanzee rather than in terms of "insight" or some other vague and highly complex mental process

Not only is an understanding of the development of general

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[1]Acknowledgement is gratefully made to Dr. C G Hartman of the Department of Embryology, Carnegie Institution of Washington, Baltimore, Maryland, for the donation of the subject of known parentage and gestation age, and to Dr. C. J Warden, of the Laboratory of Comparative Psychology, where the investigation was carried out.

modes of primate response essential to interpretation of experimental data, but it likewise enables the investigator to formulate a problem more in accord with the naturalistic behavior systems of the animal. Thus the elaborate and highly controlled experimental investigation must take into consideration a wide variety of factors specific to the organism to be utilized, such as dominant receptor and reactor systems, dietary (especially maximal and minimal motivating conditions), general and specific rhythms and physiological conditions, and, above all, previous life history. Nissen (24, p 4) has pointed out that "we should never be able to posit limits for infra-human capacities without knowing how these creatures act in an environment which, so far as we can know, may be infinitely more favorable for the development and expression of such capacities than is a laboratory setting"

The recent foundation and growth of institutions for the study of primate behavioral development both in laboratory and field situations, such as is fittingly exemplified by the tripartite division of the Yale Laboratories of Psychobiology as described by Yerkes (39), argue for the importance of the parallel growth of both supplementary methods of approach. It should be pointed out, however, that so-called laboratory or experimental and field or observational investigations are not antagonistic, opposite, mutually exclusive, or intrinsically different, but differ in the relative amount of control imposed upon the organism-in-environment situation. Thus in the average field study no extraneous control whatsoever is imposed either upon the organism or upon its stimulating conditions, direct observations being made of the various reactions of the animal under such naturalistic conditions. In the laboratory experiment, however, various artificial restrictions are utilized, such as *a priori* selection of a given response or series of responses for experimental study, elimination of certain stimulational cues, enhancement of particular motivating conditions, etc.

The necessity for complete data on the reactional biography of the individual organism, and in some cases control over stimulating conditions from birth onward, is now quite generally recognized. In comparing the behavior of various primate forms, serious considerations should be given to the wide differences in both anatomico-physiological and psychologico-behavioral development from primate to primate (cf. 5). As Kellogg (18) has further pointed out,

comparative psychology frequently fails to recognize the tremendous rôle played by environmental influence upon captive wild animals both prior and subsequent to their laboratory debut. Any one who has had first-hand acquaintance with the usual capture and transportation conditions of wild animals will often wonder how such animals have ever been successfully used for behavior research. Any such wild animal who adapts to a strict laboratory routine has exhibited a far greater degree of behavioral modifiability than is required or produced by the average experiment.

The writer has elsewhere (5) reviewed the literature dealing with the developmental aspects of the early behavior of the *Macaca mulatta,* and has discussed both the implications and possibilities of such research. That such studies are as yet surprisingly few indicates the complex of difficulties attendant upon any undertaking of this nature, as well as the past failure to recognize the various potentialities, both theoretical and practical, of this research It is satisfying to note, however, that psychological and psychobiological research on the development of infra-human primates is increasing both in amount and in span of undertaking, and the resulting material is rapidly becoming data for a more inclusive science of comparative or evolutionary psychology (cf. 6)

Problem

The present article reports fragmentary data on the second year development of a rhesus monkey *(Macaca mulatta),* reared for one and one-half years in isolation from its mother and other members of the species, and subsequently housed with other monkeys both of a similar and different species The subject, a male, was subsequently given the name "Kias." The animal was born in the Laboratories of the Department of Embryology, Carnegie Institution of Washington, Baltimore, Maryland, being the son of No 106 of that primate colony Birth occurred in the early morning of October 9, 1932, after a gestation period of 167 days The infant was forcibly taken from the mother on the morning of October 12, three days after birth, and transferred by automobile directly to New York, where it has since remained in the Laboratory of Comparative Psychology of Columbia University.

Throughout the subsequent two-year period, there was no attempt at tuition, nor was the animal reared as a pet Contact with

humans and other animals was kept at a minimum during the first one and one-half years, involving only the feeding and observational periods, after which the subject was housed with other monkeys and allowed to adapt and react with a minimum of external interference. As previously stated (5), it should be emphasized that the task was attempted as an exploratory investigation or pioneer study, the object being to test the *feasibility of rearing an infant monkey in isolation*, with the attending problems of diet, housing, and general care, and all other purposes were subordinated to this primary aim. Observations are thus often brief and fragmentary rather than final and conclusive, and this is all the more true of the second year of development, since time for observation was limited. It was deemed worth while to present a few of the most outstanding data, however sketchy and incomplete, as a further chapter in the reactional biography of the subject. The continued physical and behavioral development of the subject testifies to the realization of the primary purpose of the project, and it is hoped that the infant *Macaca mulatta* will be increasingly utilized in future comparative psychological research.

The first year development has been described in detail in a previous report (5), and familiarity with the material therein presented is necessary in order to grasp the relative significance and larger *Gestalt* of the present data. In order to avoid duplication as much as possible, many accessory data have been omitted in the present paper, and it is hoped that the reader will correctly regard the data reported in the following sections as as a mere continuation of the previously reported investigation. As in the previous report, not only is the gradual development of various behavior segments described, but *an attempt is made to correlate the acquisition of the various reaction systems with the particular stimulating circumstances which produced them.* The sudden change of the subject from an experimentally imposed situation of complete isolation to one of intimate association with other monkeys throws additional light upon the nature of certain underlying behavior mechanisms.

Habitat

Having been periodically transferred to increasingly larger quarters at various times throughout the first year (cf. 5, pp. 51-52), the infant macaque, then over five months old, was finally housed

in a standard monkey cage in an isolated part of the primate room This cage was 28 x 35½ x 34 inches, with a front door of 1-inch diamond mesh, and with a wooden shelf 18 inches above the floor. A ¼-inch galvanized grill floor was situated above the sawdust floor pan. Here the animal was reared in continued isolation throughout the remainder of the first one and one-half years, at which time, on April 9, 1934, it was transferred to a similar cage within the primate arena This arena is composed of two double rows of cages one on either side, facing each other, the ends and top of the intervening space being screened in with 1-inch diamond mesh so as to form a central enclosure or runway 6 feet wide, 13 feet long, and 7 feet high. Here the subject could be daily allowed to exercise and play, both alone and with other selected animals The daily 30-minute period of Sunlamp stimulation was continued throughout the second year

Dietary

The standardized Columbia weekly feeding schedule for monkeys, begun at the eight month (cf. 5, pp 52-54), was continued throughout the second year (cf below) As before, a cod liver oil preparation was also employed daily, made from Squibb's Adex Tablets, with Viosterol, 10 D, powdered and mixed with Lactophos (bone meal). The daily evening ration of banana was partially slit longitudinally and a small amount of this powder sprinkled inside, thereby insuring a certain constancy and control in the amount taken, with a minimum of trouble and inconvenience to both investigator and animal This diet proved most satisfactory, as is testified by the steady increase in weight (cf Results) and by the fact that severe diarrhea or other pathological symptomatology was not evidenced at any time throughout the two years

Standardized Columbia Weekly Feeding Schedule for Monkeys

	8 00 A M	1 00 P M	6 00 P M
Monday	Milk & Eggs	Boiled rice, Celery	Banana
Tuesday	Milk & Eggs	Boiled potato, Beet	Banana
Wednesday	Milk & Eggs	Wholewheat bread, Lettuce	Banana
Thursday	Milk & Eggs	Boiled rice, Spinach	Banana
Friday	Milk & Eggs	Wholewheat bread, Celery	Banana
Saturday	Milk & Eggs	Boiled sweet potato, Carrot	Banana
Sunday	Milk & Eggs	Wholewheat bread, Lettuce	Banana

Also small amounts of apple, orange, raisin, sunflower seed, and peanuts

Discussion of Results

In accordance with the general plan utilized in the previous study (5), the more outstanding observations of the subject's second year of reactional development are presented in three sections: (1) Physical Development, (2) Sensorimotor and Simple Behavioral Development, and (3) Complex Behavioral Development Again may we point out that such a division is quite arbitrary, but serves as a convenient schema for classifying the oftentimes scattered and fragmentary observations As previously stated (cf above), no attempt is made to portray the complete behavior repertoire of the subject, but rather to present certain of the more interesting and genetically significant data.

1. *Physical Development* The average monthly weight of the subject throughout the second year is shown numerically in Table 1 and graphically in Figure 1. Measurements were taken weekly in all but two cases (periods 23 and 24), for which three and two weights were recorded respectively. The figures presented are the averages of the readings taken for each successive 28-day period.

Inspection of these data will show that the subject continued to increase rapidly in weight during the second postnatal year, although the amount or degree of such increase became gradually diminished (cf. 5, Table 2 and Plate I, pp. 55-56) The subject weighed 422 grams, or 14 9 ounces, at birth (Oct. 4, 1932), 1508 grams,[2] or 53.1 ounces, at 1 year of age (Oct 4, 1933); and 2013 grams, or approximately 71 ounces, at the age of 2 years

TABLE 1
Average Monthly Weight During the Second Year

Age*	Average weight (grams)	Age*	Average weight (grams)
14	1544	21	1875
15	1606	22	1909
16	1631	23	1937
17	1698	24	1964
18	1753	25	1971
19	1789	26	2003
20	1832		

*Successive 28-day periods

[2]Weight at age of 52 weeks (5, p 55, Table 2) misprinted as 1580 grams, should read 1508 grams

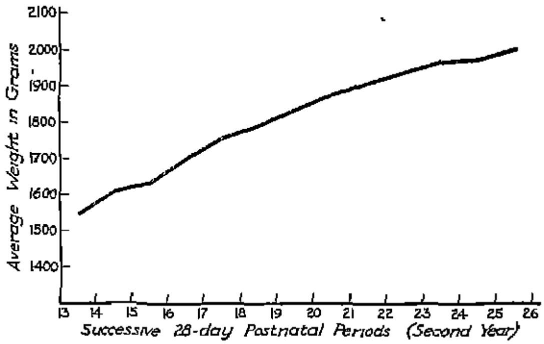

FIGURE 1

AVERAGE MONTHLY WEIGHT DURING THE SECOND YEAR

(Oct. 4, 1934). These figures are slightly lower but in general corroborate those given by Schultz (28), who has reported tentative average weights of 1646 grams (8 cases) and 2450 grams (6 cases) at the end of the first and second years, respectively. Thus during the first year the present subject showed an increase of 1083 grams in body weight, whereas only 508 grams were gained during the second year, less than half of the first year growth Since the data are for 28-day periods, all minor fluctuations are necessarily omitted, although inspection of the original weekly (and on a few occasions, daily) measurements yields the fact that with increasing age such fluctuations become less apparent, relative to the weight of the animal

The disproportionately large head and ears and small hind quarters, markedly present during the earliest postnatal days, gradually disappeared, so that by the end of the second year Kras had definitely assumed the bodily proportions of the adult *Macaca mulatta* (cf Schultz, 28) The hair, straight and medium in texture, has attained the varied length, density, and brownish color of the typical macaque, and is characteristically distributed over the entire body surface with the exception of the upper eyelids, nipples, ischial callosities, palms, soles, and terminal phalanges (cf 15). The facial wrinkles, gradually decreasing from birth in both number and degree, have completely disappeared. The testicles remain undescended, clearly visible in the canal some distance above the scrotum

2. *Sensorimotor and Simple Behavioral Development.* The *sensorimotor development of the infant Macaca mulatta* has been described in a preceding connection (5) as being virtually complete by the middle of the second postnatal week, and hence need not be discussed here. Subsequent practice, however, especially in activities involving motor adjustments, resulted in finer differentiation of the specific behavior segments or reaction components, as well as an increasingly wider variety of such intricate responses to an increasingly larger number of stimulus objects and events. Not only did new objects acquire additional stimulus functions or meanings, but many of the responses formerly made to certain stimuli were lost, or rather, replaced by other patterns of reaction.

Sleeping, so frequent during the earliest days, was seldom noted in the daytime during the second year. The specific overt pattern remained largely unchanged from approximately the second month, consisting in sleeping with the body bent forward, the legs flexed and drawn up under the body, and the arms extended forward and outward to form a cushion for the head.

Yawning, not observed during the first year, was subsequently noted on several occasions. The mouth was partially opened and the lips drawn back on either side of the mouth, exposing the teeth. This is a more or less typical reaction pattern of the macaque, and differs from yawning in the typical human animal in that in the latter subject the mouth is usually opened wide and the lips are drawn taut more in the vertical than in the horizontal plane. *Coughing* and *choking* were seldom observed, this decrease in frequency probably being due to more efficient use of the masticatory and deglutitory mechanisms. *Sneezing* was not observed during the second year, nor could it be elicited by tickling the inner nostrils with a horse-hair point. The nose and entire facial region became wrinkled upon such stimulation, but no sneezing resulted. The writer would not wish to conclude that the mechanism was absent, however, since more adequate stimulation of the internal membranes might very likely elicit the reaction. As would be expected, the *lid reflex* or *rapid winking response to a non-visual stimulus* showed no observable change

Responses which we have characterized as *mouthing, muzzling, biting* (non-masticatory), and *oral exploration,* commonly exhibited by the infant macaque in the earliest days, had practically disap-

peared by the fifteenth month. Only on occasions of extreme emotional stimulation and excitement did Kras resort to such behavior (cf. below). Thus these biting or mouthing responses were originally the precursors of modified *sucking reactions* (cf 5, pp. 67, 80), which in turn partially gave way and were replaced in many cases by other more adaptive forms of behavior As in the case of their predecessors, the sucking reactions remained relevant only to certain (i e, liquid food) situations, and were no longer elicited by a wide variety of stimulation

The early forms of *crying* or *vociferation* persisted with certain modifications of patterning, and the stimulus conditions for such behavior became widely varied. This behavior, with special reference to certain acquired vocal and stimulational characteristics, will be discussed in the following section on "Complex Behavioral Development"

The *scratch reflex* or *scratching reaction* was infrequently noted, having disappeared as a common occurrence as early as the fourth week (cf 5, p 68) The *righting reflex* continued to be exhibited whenever the animal was released ventral side up, and was executed with a minimum of useless and uncoordinated movements The *grasping reflex, clutching* or *clinging response,* involving the more complex reactions of *contact seeking* and the *seeking of bodily support,* the most outstanding and persistent behavior patterns during the early stages of behavioral development, gradually diminished both in frequency and in degree of manifestation By the end of the second year, such reactions were observed only in cases of severe emotional excitement (cf below). Whereas it was once almost impossible to force the infant to relinquish his grasp on a suspended horizontal bar (5, pp 69-72), such reactions were but occasionally observed at one year of age, and by the end of the second year the subject would not cling to the bar under any conditions whatsoever, but would immediately drop to the floor These data are analogous to those reported by Watson, Gesell, and others for the human infant As previously pointed out (5), this transition in grasping or clinging behavior was gradual, and its decreasing manifestation was correlated with the acquisition and development of locomotion and other complex sensorimotor coordinations The above statements are made with reference to what may properly be termed the grasping or clinging reflex, manifested whenever the usual means of support was removed (e g, clinging to a suspended

bar in mid-air), and do not refer to cases in which the monkey grasped or clung to a desired object, such as a piece of food. The grasping response *per se* undoubtedly remained intact, although it was no longer elicited by *stimulation involving* loss of support, the entire picture being further complicated by the animal's wide range of adaptive, substitute, or alternative reactions.

By the end of the second year, *locomotor abilities,* including *walking, running, jumping, climbing,* and related activities, had reached a state of perfected coordination and efficiency equal to that of the typical adult macaque. This development was at first observedly retarded by the artificial isolation and attendant restriction of stimulation and response experimentally imposed upon the subject for the first one and one-half years, although the subsequent one-half year period of association with other members of the species was sufficient to make up for the minor initial deficiency. There was, however, a tendency for the subject to rear up, stand, and walk for short distances on his hind feet alone more often than in the average macaque. This observation was made as early as the beginning of the fourth month (5, p. 73), and continued to hold for subsequent periods, although tuition in the trait was never given.

Likewise, the *tendency to climb or orient upward* was not observed during the second year. As pointed out in the article dealing with first year development (5, p. 74), *upward climbing reactions to the vertical stick and upward orientation on the elevated platform,* markedly present immediately subsequent to birth, tended to disappear after the infant had learned to walk and make a wide variety of substitute adaptive reactions. This finding, a corroboration of the results of Tinklepaugh and Hartman (32), is closely related to the observed disappearance of the *grasping reflex* (cf. above), since the upward climbing reaction is obviously complicated by the basic grasping, clutching, and contact-seeking responses, by emotional factors, and in fact by the developmental status of the entire behavior repertoire of the subject

Play behavior, consisting of *running, jumping, climbing,* and *leaping upon* and *seizing* objects, with attendant *vocalization,* showed a pronounced increase immediately after Kras was housed in close proximity to other monkeys. When let out into the central arena or runway, he would run from side to side, climbing up the screening at the end of the enclosure, only to jump to the floor again

He would often climb up on the heavy diamond mesh forming the door of another animal's cage, and would frequently swing back and forth on the door of his own cage, alternately opening and closing it. The last few weeks of the second year, however, seemed to show a slight decrease in general amount of spontaneous play activity. This may have been a mere artifact, or may possibly be a precursor of a less active existence Carpenter (4, p 79 ff.) has recently observed that the amount of play activity shown by young howling monkeys in their native habitat "increases until the juvenile 1 stage, and then there is a rather sharp decline to a minimum of play in adult animals" It is also interesting to note that rarely did the present subject, during the course of his climbing and random play activities, invert his head or body. Descents from a height were almost invariably made either in the human fashion, hind feet first, or by jumping Additional relevant material regarding play activities, especially as influenced by social stimulation, will be presented in the following section.

Too much emphasis cannot be placed upon the remarkable degree of *sensorimotor coordination* attained by the two-year-old subject. Whereas during the early days, "misjudged distances were the rule rather than the exception" (5, p. 76), later reactions were perfected and executed with such precision, speed and timing, that they often escaped human observation Especially outstanding was behavior predominantly characterized by *prehension* and *manipulation* of stimulus objects Use of the pedal extremities, however, was definitely inferior to that exhibited by the typical macaque. This deficiency may with a high degree of probability be attributed to the experimentally imposed isolation, with lack of stimulation and practice conducive toward the development of such behavior.

Use of the cheek pouches, first noticed at 107 days of age (5, pp. 76, 81), became a common behavior trait, not unlike that of the average rhesus monkey This topic will be discussed in connection with feeding behavior in the following section.

3 *Complex Behavioral Development.* During the second year, *feeding behavior,* including biting, chewing, and swallowing, was observed only in situations wherein food was available, showing that differentiation with respect to such stimuli had been satisfactorily accomplished. This behavior was in marked contrast to the early tendency to bite immediately at any object held within the

infant's visual field (5, pp 78-79). If food was presented which had never before been experienced, Kras would seize and convey it to the nose for olfactory inspection, before putting it in his mouth. When satiated, the subject no longer made the once characteristic thrusting and slapping movements of the arms and hands, but left the food at once and reacted to other stimuli If the food were removed before satiation had occurred, however, the same type of violent emotional response was made as formerly, involving puckering of the mouth, vociferation, frequent thumbsucking, plus a new addition, jumping up and down

Liquid food was taken from the pan by the combined process of *suction* and *lapping* movements of the tongue. The repeated *grasping* reaction with the hands and fingers while feeding, involving alternate opening and closing of the hands and digits, which at first was made with such frequency but which disappeared by the tenth postnatal week (5, pp. 80-81), was never again observed in a food-taking situation, although such behavior did reappear during violent emotional stress. In the natural, undisturbed mother-infant situation, these early clutching reactions, in so far as they are elicited by and directed toward the ventral furry surface of the supporting mother (16, 31, 32), undoubtedly have some adaptive value, and such behavior was "carried over" and exhibited by the infant Kras in response to feeding situations after experimental isolation from the mother, the diminuation and subsequent disappearance of such reactions taking place in conformity with a principle not unlike that of experimental extinction.

The *cheek pouches* were frequently used for storage of food, especially if the subject was fed in the immediate presence of other monkeys. Food could thus be hurriedly taken, retained, and subsequently eaten over a period of time, being pushed out into the mouth cavity with the hands or shoulder blades. *Food preferences* were also exhibited, milk, orange juice, and mush or gruel being most readily taken throughout the second year. It is of importance to note that these liquid or semi-liquid foods constituted the exclusive diet up to the age of 5 months (cf. 5, p. 53), and maintained their preferential value from the beginning Apple, raisin, peanuts, and sunflower seed, having the highest motivating value for most of the monkeys in the Columbia colony, elicited secondary preferential reactions in the present subject In fact it might be said that in

general the preference was inversely proportional to the dryness and solidity of the food. Banana was relatively well liked. Kras *did not actually peel it, however, as does the typical monkey, even* when the peeling is later to be eaten This lack of specific differential response to peeling and internal fruit characterized the subject's behavior from the first, as was pointed out in the previous report (5, p 82), and certainly cannot be attributed to lack of requisite sensorimotor mechanisms Only occasionally, when the relatively harder peeling offered more resistance to the teeth, did Kras push back the peeling a few millimeters with his thumb. The succeeding bite, however, consumed both peeling and enclosed fruit

No *coprophagous behavior* was observed at any time Whereas on a few occasions during the first year the infant manually and olfactorily examined the feces, although never tasting or eating them, he seemingly learned to avoid them entirely, for even such cursory interest and examination was never noted during the second year period

Vocalization continued to be less frequent than in the average macaque of the same age The repertoire remained practically the same as that previously reported for the thirteenth and succeeding weeks (5, p 84), with the single addition of what may be termed a "hunger-anticipation cry," which appeared during the latter part of the nineteenth month, after the subject had been housed for 2-3 weeks in close proximity to the other monkeys In general, the following four types of cries could be distinguished by the end of the second year

1 *"Play cry,"* consisting of a clear, shrill, and high-pitched cry made with the lips pursed and rounded. A given cry somewhat resembled the sound of the double vowel in the word "food," although slightly slurred, and increased and then decreased in pitch

2 *"Fear-Pain cry,"* consisting of a scream of rapidly varying pitches, made with the mouth open and the entire face wrinkled and distorted.

3 *"Food-Contentment cry,"* consisting of a soft, short, guttural, and slightly hoarse noise, often accompanying eating, gentle stroking or handling, or attainment of contact or support after emotional stimulation, and often associated with rapid opening and closing of the lips ("mouthing response").

4 *"Hunger-Anticipation cry,"* consisting of a clear, falsetto cry of descending pitch, made with the lips in their normal position and the mouth partially open

The difficulty and necessary artificiality of reducing the complex vocal behavior of the *Macaca mulatta* to a simple classification cannot be overemphasized If the restrictions and limitations of the classification are kept in mind, however, it does seem both empirically justifiable and profitable to isolate these major types of vocal behavior, and to consider other cries as modifications of the above four The repertoire of the present subject at two years of age seems to have been fully as complete as that of the other, older monkeys in the Columbia colony The "food-contentment cry" was more fully developed and frequently elicited than in the other macaques. With respect to the fourth or "hunger-anticipation cry," it is interesting to note that it was acquired in the most exact detail from the other monkeys At no time was it heard during the period of isolation, prior to the nineteenth month Later, however, when the experimenter would enter the laboratory in the morning just before feeding time, the sound of his footsteps and the opening door would immediately elicit the cry from Kras and the entire colony. Similarly, the closing of the ice-box door caused the same vocal reaction, which did not occur at the closing of cabinet and other doors not associated with or conditioned to food-taking situations

Prehension, manipulation, and *eye-hand coordination* have been discussed in the preceding section *Handedness* continued to be non-preferential, the subject being completely ambidextrous with respect to frequency and efficiency of manual prehension and manipulation *Play behavior* has also been discussed at length above It might here be added that, at approximately the nineteenth month, Kras developed a more or less indirect, circuitous, or "stalking" type of play activity which was not exhibited prior to his entry into close association with the other monkeys at 18 months of age (cf. 5, p 75) Although the account of the development of their non-isolated rhesus monkey does not go beyond the fifteenth week, Lashley and Watson (22, pp 137-138) describe the play of their subject as "beginning as simple thrusting out of his hands against his mother," and state that "it developed rapidly into the more complex stalking of various objects in the cage." They also observed that "the stalking play was at first directed toward all conspicuous objects in the cage, but as the baby learned to eat solid food his attention became more and more directed toward this, and his play activities to center around it" Thus the present finding

would be expected in the light of Lashley and Watson's data, i.e., the absence of such activities during an extended period of complete isolation, and the rapid acquisition of such behavior when the animal was placed in a more competitive situation wherein such reactions were frequently practiced by all concerned

This noticeable increase in *play behavior* has been described in the previous section dealing with "Sensorimotor and Simple Behavioral Development." Such an increase may be characterized as a gradual change from the original self-composed or more nearly "introverted" type of play behavior toward a more objective or "extroverted" mode of response In this connection, Lashley and Watson (22, p. 138) make the following statement in regard to their infant macaque.

> "Self imitation," so marked during certain stages of the human infant, was almost entirely lacking The few actions which might be so interpreted were those of climbing and leaping, with evident enjoyment of the activity itself . In most of his play, however, his interest seemed to be centered in external objects rather than in the movements themselves.

It seems clear, however, that in the present case at least, this external reference was slowly acquired during the development process, and that the acquisition of such behavior, undoubtedly retarded by the experimentally imposed isolation, was rapidly enhanced by placing the monkey with other animals in a more extensive milieu of stimulating conditions

Little variation in the patterned *emotional behavior* of the subject took place during the second year, although the nature and range of stimuli eliciting a given emotional response were considerably altered The greatest change occurred in connection with the *"fear reaction,"* whose pattern has been previously described (5, p 86) This response pattern, violently elicited (postnatal) by removal of contact or support but not originally elicited by loud sounds, came, by the end of the second year, to be evoked by certain loud and novel sounds, such as the bark of a dog or the sound of breaking glass, and at the same time disappeared in response to stimulation by removal of support The latter disappearance may be easily understood in terms of the acquisition of other modes of adaptation to the once "fear-evoking" removal of support, and might have been predicted on the grounds of behavioral development. Similarly, the later potency of certain loud and novel sounds as instigators of

"fear" behavior may quite likely have been the result of conditioning received subsequent to the eighteenth month The *"rage"* or *"anger reaction"* (cf. 5, p 88) continued to be evoked by hampering or restraining the animal's movements, being accompanied by thumb-sucking and, on very rare occasions, by what we have termed the "fear-pain cry" The *"love reaction"* also showed but little change (5, p 88), and was made on occasions immediately following extreme fright or in response to certain other monkeys or to the experimenter (never to strangers). At such times the "food-contentment cry" was commonly made. In general, it may be stated that during the first two postnatal years emotional behavior became gradually less intense with increasing morphological and behavioral development

Clinging behavior, originally elicited in response to the experimenter's hand, so that the latter literally became a *fetish* for the animal, although at first without sexual significance (5, p 91), took on the function of a sexual stimulus toward the beginning of the second year, although the exact date cannot be accurately given The original traces of this behavior were greatly reinforced subsequent to the eighteenth month, at which time the infant's curve of sexual behavior rose with a rapidity great enough to be characterized as "insight" by the typical Gestaltist. A more detailed account of sexual behavior will be presented below.

Emotional fits or *tantrums* continued to result from forcibly depriving the monkey of a play or food object (cf. 5, p. 91) Similar emotional responses ensued if such a desired object was given to another monkey, and will be discussed below in connection with the more complex trait of "jealousy." If at any time a small leather belt, similar to that worn by the other members of the colony, was placed around his waist (5, p 92), Kras immediately showed the characteristic emotional grasping behavior, pulling at the belt, clutching himself, swaying or oscillating back and forth, sucking his thumb, and crying, until the belt was removed. At such times Kras would also utter the "fear-pain cry," rear up on his hind legs and go around in circles, often striking his head and body against objects in the room in his frenzy to remove the obstacle

It is of interest to note that at no time did Kras, regardless of his emotional state, make the slightest attempt to bite the writer, although on rare occasions he would playfully bite a stranger at

the slightest provocation. Nor would he utter a cry if hurt or painfully stimulated by the experimenter. The prick of a needle would elicit only contortion of the face and sporadic escape movements similar to those made if he were forcibly restrained. The "fear-pain cry" thus rarely denoted pain *per se*, but more often anger or other antagonism resulting from such stimulation.

It will be recalled from the original article on first year development (5, p 92) that *oscillating* or *swaying* movements were present from the third postnatal day, being "usually made in an emergency and highly emotional situation" The exact pattern of response involved either placement of the hands and forearms on the floor directly in front of the body or grasping the thighs or hind legs, the total body maintaining the sitting posture, and the making of rapid and rhythmic movements, the body being alternately raised and lowered, i e, swayed back and forth In the original report, the writer mentioned unpublished observations by Nissen on the occurrence of such behavior in the chimpanzee, as well as the previously unreported occurrence of similar reactions in the isolated infant macaque of Engle Although such activity is superficially similar to that often occurring in sexually stimulating situations, it should not be confused with attempted copulatory behavior, since its ontogenetic origin, particular stimulational antecedents, and component details are entirely different in character.

The *"mouthing and tongue response,"* present from the seventy-first day, and involving rapid opening and closing of the mouth or lips and corresponding thrusting and withdrawing movements of the tongue, and often occurring in conjunction with the "food-contentment cry," was also frequently observed during the second year. As formerly, the response was often made before or after feeding or when the monkey was stroked or petted following extreme fright (cf 5, p 92). Subsequent to the twentieth month, however, the response was additionally observed in sexually stimulating situations in which the subject was attempting to copulate with some other monkey or with the experimenter's arm The sexual significance of such a "mouthing response" prior to copulation has been recently reported by Carpenter (4, p 82 ff) in his field study of the howler monkey In describing this "provocative" behavior of the howler in its native habitat, Carpenter concludes: "The behavioral aspects preliminary to copulation are the rhythmic tongue move-

ments, provocative posturing, and exploratory behavior" Such reactions were not observed in other, non-sexual situations, as in the case of the present subject, although such a deficiency might be due to inadequate opportunities for observation or to the lack of adequate stimulation such as that received by the present subject

Thumbsucking, another emotional accompaniment, also persisted throughout the second year, although the total amount of time spent in such activity decreased, owing to the larger and more varied repertoire of substitute behavior. The great toe of the left hind foot continued to be favored (cf 5, pp. 92-93), and as a result became greatly enlarged, the discrepancy in size between the great toes of the two feet being of the ratio of 2 to 3 The act was so firmly fixed that at times Kras would traverse the length of his cage on three legs, the great toe of the fourth remaining "contentedly" in his mouth.

Several cases of interesting *mannerisms* and *"habit residuals"* may be parenthetically noted. The upward motion of the hind foot as if to place the great toe in the mouth was cited in the previous report (5, p. 93) In the light of the recent work of Hull, it would be highly informative to know if such a response were "anticipatory" and hence connected with any salivary disturbance The disappearance of the repeated grasping movements formerly made while drinking (cf. above) illustrates the abandonment of another such residual. A further example of habit residual is illustrated by frequent clutching of the right eyebrow with the corresponding hand. No foreign particle was detected in the eye itself, and the mannerism was probably due to the extremely long and projecting eyebrows which once undoubtedly partially obstructed the infant's visual field The reaching response persisted, however, although the longer eyebrows were carefully cut.

The *sexual behavior* of the present subject was particularly informative, and deserves separate consideration quite apart from its emotional aspect The experimentally imposed conditions under which the animal lived and developed showed a remarkably high correlation with the sexual behavior patterns exhibited from time to time in the course of reactional development. The following statement was made in the report covering the first year development:

> As would be expected from other studies on isolated animals, the sexual behavior of the present subject was practically nil The swaying movements and mouthing reactions, although

> superficially resembling modifications of sexual behavior, had no such actual significance The testes did not descend during the first year, , nor was erection observed during this period, although it has been subsequently noted In striking contrast, Lashley and Watson . observed such a reaction on the sixty-first day. (5, p 93)

As pointed out above, the testicles remained undescended during the second year Erection was first noted during the fifty-ninth week, and continued infrequently to appear, although prior to the eighteenth month it was rarely accompanied by other overt behavior. Occasionally Kras would touch the erected organ, but such manual manipulation was by no means more frequent than similar behavior in response to other relatively erogenous areas of the face and extremities Thus there was a minimum of explicit sexual behavior during the period of isolation, and the relatively late incidence of the then unconditioned and more or less strictly biological act of erection, in contrast to the data of Lashley and Watson, further substantiates this fact The behavior of the subject, both when alone and when placed with other monkeys for a short observational period, was consistently *non-sexual.*

After having been permitted closer association with other monkeys from the age of 18 months, however, Kras began to exhibit such sexual behavior The earliest reactions consisted of olfactorily exploring the body of the other monkey, clutching some part of the animal's body, usually the leg or back, and making a few sporadic thrusting movements of the pelvis Erection was not always present on such occasions, and no preference was evidenced for female over male animals nor for the rhesus over the cebus or capuchin types. In fact such reactions were on a few occasions observed in response to a rag or other soft object By the end of the second year, the sexual behavior had become more or less localized with respect to the genital regions, and there was a general although by no means exclusive preference for female animals. The arm and hand of the experimenter continued to function as a sexual stimulus, as has been described above in connection with the "mouthing and tongue response." The following quotation from the laboratory notes for October 5, 1934 is a typical illustration of sexual behavior at the end of the second year in response to a very tame and good-natured female macaque, approximately 7½ years of age:

> When turned out with Bright Girl today, Kras played around in the arena for 4-5 minutes without apparently noticing her. He finally approached and grasped her around the waist from the rear, after smelling the vaginal and anal regions several times. Erection appeared and, as she remained crouching on the floor, he strengthened his hold around her waist with both arms, and made the characteristic rhythmic thrusting movements of the pelvis, the tail curling up under the legs Bright Girl remained passive, and the movements ceased within 10 seconds

These data are in full accord with the findings of Hamilton (13, 14), Tinklepaugh (29), and Zuckerman (43) on monkeys, and other investigators on infraprimate mammals in regard to experimentally produced homosexuality and other sexual aberrations and the consequent general importance of stimulating circumstances in conditioning fundamental drives and action-tendencies. *The important thing, so far as the description of behavior is concerned, is not the constitution and relative strength of the so-called basic drives of the organism, but rather how such "drives" are conditioned, for it is only this historical or biographical factor which can adequately account for the specific strength and patterning of behavior.*

The *reactions of the subject to other animals* continued to be positive in all cases with the exception of certain monkeys who slapped and bit at Kras whenever he approached, and even in such cases definitely aggressive behavior was usually exhibited. The original clutching reaction (5, pp 94-96) of course disappeared, just as it had in response to inanimate stimuli. Kras developed certain *preferences* and *aversions* for particular monkeys, however, and these led to the formation of *social groupings*, incipient stages of phenomena which have been described by Bingham (2), Carpenter (4), Nissen (24), Zuckerman (43), and others for infrahuman primates, and by Bühler, Gesell, Jones, and others too numerous to mention for the human child Thus, for example, Kras and Bright Girl constituted one such early social grouping, quite independent of sexual behavior. They would climb around the cage and play together, even getting in and out of each other's cages If another caged monkey would exhibit anger and menacingly jump forward to the door of its cage, both Kras and Bright Girl would approach and try to seize or bite the monkey's hands through the cage door This particular grouping was weakened, however, as a result of frequent attempted copulation on the part of Kras.

Aggressiveness characterized the behavior of the subject throughout the second year. Behavior not dissimilar to that termed *jealousy* was also frequently exhibited. If food were given to another monkey, even to one for whom Kras had formed a positive attachment, he would often display a series of violent reactions, jump up and down, put his ears back against his head, and utter the "hunger-anticipation cry" followed immediately by the "fear-pain cry," and if these were to no avail, he would finally resort to thumbsucking. On rare occasions he would become bold enough to dash up and try to snatch the food from the other monkey's hand, although he was usually briskly cufted away, after which he would not dare to repeat the attempt for some time. He would become quiet immediately if given food, making the "mouthing and tongue response" and uttering the "food-contentment cry."

Certain early *perceptual* reactions of the subject, occurring prior to experience with a particular object or class of objects, are not without interest. The evolution of the subject's *reaction to his mirror image* was described in the previous report (5, p. 98) and showed little further change. In fact it became increasingly difficult to get the animal to attend to a given stimulus object, since such a wide variety of stimuli and reaction-systems was continually competing for his attention. On one occasion during the fifty-fourth week, however, Kras was seen suddenly to place his ears back and jump forcefully against a large pane of glass, in which he no doubt saw his reflected image. The *lack of differential response to the peeling and fruit of a banana* has been discussed above in connection with feeding behavior. At 16 month of age, the *response to ice* was first tested. When a piece of ice was placed on the floor of his cage, he looked curiously at it, slapped at it, and then explored and finally seized it in both hands and jumped up onto the shelf of the cage. He held the ice for approximately three minutes, licking it periodically and occasionally trying to bite it. Finally it was abandoned on the floor, although he returned and continued to play with it from time to time. Two further interesting observations on perceptual behavior during the first year were unfortunately omitted from the previous report. During the forty-fifth week, Kras was seen to *reach out and attempt to grab or manually manipulate smoke rings* accidentally blown by an observer. Similarly, at approximately one year of age, he was observed to jump up into the laboratory sink and *endeavor*

to climb up a smoothly flowing stream of water The above examples of objectively inappropriate reactions, although sketchily drawn, illustrate certain stages in the development of perceptual adaptations, and are not without value for an empirical or behavioral theory of space and object perception. Such subtle conditionings which inevitably occur during the reactional biography of any organism can be profitably investigated only by means of a genetic approach. The work of Piaget and others on the acquisition of perceptual and conceptual reactions in the human child finds many counterparts in the field of animal behavior, and such a field offers unlimited opportunities for further research

Lastly, it may be stated that neither *auto-grooming* nor "social" or *inter-individual grooming* (cf. 5, pp 98-101) was exhibited by the present subject during the first two years of life. Whether such a behavioral deficiency was due to the absence of dirt and body parasites or whether it may be attributed to the lack of opportunity for the early acquisition of such a reaction pattern cannot be stated. The data nevertheless cast considerable doubt upon the hypothesis that grooming is an instinctive primate function or that it is dependent upon neural or neuro-muscular maturation.

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LE DÉVELOPPEMENT PENDANT LA DEUXIEME ANNÉE D'UN SINGE RHÉSUS (*Macaca mulatta*) ÉLEVÉ DANS L'ISOLATION PENDANT LES PREMIERS DIX-HUIT MOIS

(Résumé)

Cette étude est une continuation d'une étude déjà rapportée, et decrit le développement pendant la deuxième année d'un singe rhésus (*Macaca mulatta*) élevé dans l'isolation complète de la mère et des autres membres de l'espèce pendant les premiers dix-huit mois, et subsèquemment logé avec d'autres singes dans les quartiers généraux des primates du laboratoire

L'auteur appuie sur le besoin d'une connaissance détaillée de l'histoire psychogénétique spéciale ou biographie réactionnelle d'un animal expérimental quelconque employé dans la recherche du comportement L'autre partie de l'article discute l'expérience elle-même, y compris la description du *problème, l'habitat, le régime, et la discussion des résultats* Quand possible, on rapporte les données pertinentes d'autres investigations On discute les résultats sous trois titres principaux, appuyant surtout sur le troisième:

(1) le *développement physique*
(2) le *développement sensorimoteur et le développement simple du comportement*

(3) le *developpement complexe du comportement*
La dernière catégorie comprend la discussion du comportement de manger, la vocalisation, la préhension et la manipulation coordonnées, les activités du jeu, le comportement émotif, le sucement du pouce, les maniérismes, les réactions anormales et les restes des habitudes, le comportement sexuel, les réactions aux autres animaux, les groupements sociaux, les principaux traits de personnalité, le comportement perceptif et conceptif, et les soins de propreté

Non seulement on décrit le développement graduel de ce comportement, mais on essaie de corréler l'acquisition des divers systèmes de réaction avec les circonstances stimulantes spéciales qui les a produits Le changement soudain du sujet d'une situation d'isolation complète imposée expérimentalement à celui d'association intime avec les autres singes rend plus claire la nature des mécanismes de comportement à la base.

FOLEY

DAS ZWEITE JAHR DER ENTWICKLUNG EINES RHESUSAFFEN (*MACACA MULATTA*), DER WAHREND DER ERSTEN ACHTZEHN MONATE IN ISOLIERUNG AUFWUCHS

(Referat)

Diese Abhandlung ist eine Forsetzung einer fruher berichteten Untersuchung und beschreibt das zweite Jahr der Entwicklung eines Rhesusaffen (*Macaca mulatta*), der in vollkommener Trennung von der Mutter und anderen Mitgliedern der Gattung wahrend der ersten 18 Monate aufwuchs, und der mit anderen Affen im Laboratorium untergebracht wurde

Der Autor betont die Notwendigkeit einer ausfuhrlichen Kenntnis der besonderen psychogenetischen Geschichte oder Reaktionsbiographie irgend eines Tieres, das zu experimentellen Zwecken gebraucht wird Der Rest der Abhandlung beschaftigt sich mit dem eigentlichen Experiment, das eine Beschreibung des Problems, Fundortes, Dietat, und eine Erorterung der Ergebnisse enhalt Diesbezugliche Ergebnisse von anderen Experimenten werden womoglich angegeben Die Ergebnisse werden unter drei Hauptuberschiften besprochen, mit besonderer Berucksichtigung der dritten

1 Physische Entwicklung
2 Sinnesmotor- und einfache Verhaltungsentwicklung
3 Komplizierte Verhaltungsentwicklung

Die letzte Kategorie schliesst eine Besprechung des Fressverhaltens, der Vokalisation, koordinierten Ergreifens und der Handhabung, Spieltatikkeiten, affektiven Verhaltens, Damensaugens, Manieriertheiten, anormalen Reaktionen, und Gewohnheitsruckstande, Geschlechtsverhaltungsweisen, Reaktionen auf andere Tiere, sozialen Gruppierungen, hervorragenden Personlichkeitszuge, Wahrnehmungs- und Vorstellungsverhaltens, und Pflegens ein

Nicht nur wird die allmahliche Entwicklung von solchem Verhalten beschrieben, sondern auch wird der Versuch gemacht, die Erwerbung der verschiedenen Reaktionssysteme mit den besonderen Reizungsumstanden zu korrelieren, die sie erzeugt haben Die plotzliche Anderung des Versuchtieres von einer auferlegten Situation der vollkommenen Trennung zu einer der intimen Assoziation mit anderen Affen erleuchtet die Natur des unterliegenden Verhaltungsmechanismus

FOLEY

THE AGE FACTOR IN REMINISCENCE: A COMPARATIVE STUDY OF PRESCHOOL CHILDREN AND COLLEGE STUDENTS*

From the Department of Psychology of the University of Missouri

GRACE O McGEOCH

PROBLEM

In a recent critical review (4) of the experimental literature on reminiscence, a phenomenon there defined as "the improvement in the recall of incompletely learned material after an interval of time without intervenient formal relearning or review," it was concluded that the relationship between age and reminiscence had not yet been established Attention was called to the fact that the results of those experiments in which apparent age differences were obtained (1, 2) did not justify the conclusion that age is a factor in reminiscence since there was a lack of uniformity in experimental conditions with the different age levels, particularly in the materials learned Moreover, Williams' experiment (6), in which the learning material was constant, did not throw light upon the relationship between age and reminiscence because his published results are in terms of the percentage of retention of the group, a criterion of reminiscence demonstrated to be inadequate.

More recently Liang[1] found no significant age differences in reminiscence in terms of the same criterion, and concluded that "the factor of age differences so much emphasized in Ballard's and Williams' findings could not be reproduced under more carefully controlled conditions so far as the aggregate percentage of retention was concerned." Liang used two age groups, 648 children whose average age was 11 2 years, and 353 college freshmen whose average age was 19.5 years, equated degrees of learning of Chinese ballad poetry, and five intervals, one, two, three, four and five days For the one- and two-day intervals, however, the percentages of children showing

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[1]The study by Luh and Liang (3) was brought to the writer's attention through the courtesy of the senior author after the completion of the present experiment.

is well above the maximum attained in Group VI (Table 2) when a 3-gm. reward was used on each trial. Results are presented in Table 6.

For Kambi the incentives used in the mixed series weighed 5 gms. and 20 gms, respectively, the short delay was 360 seconds, the long delay 600 seconds Six series of 10 trials each (Group *A*) and four series of eight trials each (Group *B*) were given. The system of alternations in Group *A* corresponded to days 7, 8, 9, 10, 7, 8, in Group *B* to days 7, 8, 9, 10 of Bokar's schedule (see above). The shorter of the two delay intervals employed in the mixed series was about twice as long as the maximum attained with a 5-gm reward in Group IX (Table 3). After completion of the Group *A* mixed series, Kambi was given 10 trials with a constant incentive of 5 gms and a delay of 360 seconds; her score was 50 per cent correct. At the end of the Group *B* series, scores of 88 per cent, 100 per cent and 75 per cent were obtained on three successive days of eight trials each 5 gms. reward, 360 seconds delay.

Table 6 indicates (1) that, under the conditions of the mixed series, the amount of incentive which the animal sees being placed into the container during the presentation period is of significance[5] in determining the accuracy of the following response, (2) that under these conditions the length of the delay interval is relatively unimportant, and (3) that interspersing large-reward trials among the small-reward trials results in a better performance (greater accuracy) with small incentives than is possible when only small rewards are used. This suggests, then, that the incentive in delayed response has both a general effect (as was also determined in the previous section) and an effect specific to the response following presentation (sight) of the incentive

Scores at Certain Delay Intervals under Varying Conditions. With the exception of the section on mixed series we have emphasized, in this paper, the effects of the experimental variables on delay limits rather than on scores at given delay intervals The main

[5]Using the formula $\sigma_p = \sqrt{\frac{p\,q}{n}}$, and combining Groups *A*, *B* and *C*, we find that the difference between Bokar's scores with small and large rewards, respectively, is 3 5 times the S D of the difference Neither of the other differences are statistically reliable, but all are consistent in direction

part of this experiment was planned to facilitate comparisons of the former kind rather than of performances at certain levels of difficulty. Consideration of the varying number of trials given in a series (errors increase towards the end of a series) and especially of the perseverative effect of the incentive, indicated above, makes it apparent that comparisons by the second method will not be unambiguous. With this warning, we present, in Table 7, a summary recapitulation of the data, in which only scores on immediately suc-

TABLE 7

Showing relative magnitude of scores at the same delay intervals when the incentive (a) is the same, (b) increases, and (c) decreases in successive test groups.

(*a*) Same amount of reward per trial

Test groups	Bokar II & III	Moos I & II	Moos III & IV	Kambi I & II	Kambi III & IV	Kambi VI & VII	Velt I & II	Velt II & III	Total number of instances
Scores the same	3	0	1	1	1	1	0	0	7
First score higher	3	1	2	0	1	1	2	0	10
Second score higher	1	6	2	2	2	2	1	3	19

(*b*) Increasing amount of reward

Test groups	Bokar III & IV, V	Moos IV & V	Kambi II & III	Kambi IV & V	Kambi VII & VIII	Velt III & IV	Total number of instances
Scores the same	4	1	0	2	0	1	8
Small reward scores higher	2	1	2	0	1	2	8
Large reward scores higher	3	3	0	2	0	0	8

(*c*) Decreasing amount of reward

Test groups	Bokar IV, V & VI	Moos II & III	Moos V & VI	Kambi V & VI	Kambi VIII & IX	Total number of instances
Scores the same	1	0	5	2	1	9
Small reward scores higher	2	2	1	1	1	7
Large reward scores higher	1	4	1	5	3	14

cessive test groups (adjacent columns in Tables 1-4) are compared. Where there are several scores at a certain level within the same group, these have been averaged. No scores appearing below the italicized numbers in Tables 1 to 4 inclusive were used in making up Table 7. Group I of Bokar's record is omitted because of the special conditions obtaining in these test series. The amount of difference between scores is not considered; the figures in the table show merely the number of cases for each direction of difference.

Analysis of Errors In Table 8 is given a partial analysis of the errors made by the several animals in successive portions of the experiment. It is seen that some of the subjects had rather decided left-right preferences or tendencies; these animals seemed to be working on the principle: When in doubt, take the right (or left) box. Of particular interest is the preponderance of errors during the last half, as contrasted with the first half, of each series. Table 8 has a total of 30 divisions in which the pertinent data are available (last three columns), in 20 of these the second half has more errors than the first half of the series, in two cases the numbers are equal. The significance of this finding is enhanced when considered in connection with the fact (see above) that the number of trials per series seems to have no effect on the scores or delay limits obtained. It is tempting to conclude that the animals anticipated or had a "set" for the length of the experimental period. A more detailed analysis of the distribution of errors, not presented here, shows that the number of incorrect responses does not increase with any regularity towards the end of the series, the error curve shows marked fluctuations

Response Time During all of Moos's trials and during the latter half of the trials given Kambi, the time elapsing between the moment when the animal first had opportunity to respond and actual initiation of overt response was measured with a stopwatch and recorded. Inspection of the records indicates a small positive correlation between average response time and number of errors in a series, within a series wrong responses have, on the average, slightly longer response times than have correct responses. The amount of incentive used in various test groups does not correlate with average response time.

SUMMARY

Four young chimpanzees were used in delayed response situations

TABLE 8

Showing Number of Errors Made on Left and Right Sides, and During the First and Second Half of Each Series of Trials

	No of trials	Total errors	Errors on Left	Errors on Right	Errors in first half of series	Errors in second half of series	Errors last vs first half of series*
			Bokar				
Preliminary training	458	101	63	38	45	56	+
Group I	240	20	13	7	9	11	+
II	300	44	18	26	13	31	+
III	140	18	14	4	3	15	+
IV	100	4	2	2	3	1	—
V	160	8	5	3	3	5	+
VI	35	4	0	4	2	2	=
Mixed series	100	16	8	8	8	8	=
Total	1533	215	123	92	86	129	
			Moos				
Preliminary training	20	4	No record				
Group I	360	75	31	44	29	46	+
II	100	13	8	5	9	4	—
III	180	33	13	20	9	24	+
IV	70	8	5	3	3	5	+
V	100	6	1	5	4	2	—
VI	74	5	2	3	5	0	—
Mixed series	40	5	2	3	3	2	—
Total	944	149	62	83	62	83	
			Kambi				
Preliminary training	40	16	8	8	9	7	—
Group I	90	29	13	16	12	17	+
II	70	17	8	9	8	9	+
III	80	23	13	10	6	17	+
IV	90	17	6	11	9	8	—
V	100	9	1	8	1	8	+
VI	110	18	9	9	10	8	—
VII	70	11	6	5	4	7	+
VIII	120	11	7	4	3	8	+
IX	120	21	8	13	6	15	+
Mixed series	92	13	4	9	4	9	+
Total	982	185	83	102	72	113	
			Velt				
Preliminary training	120		Record incomplete				
Group I	110	17	13	4	7	10	+
II	70	21	18	3	8	13	+
III	50	12	10	2	4	8	+
IV	100	15	14	1	5	10	+
Total	450	65	55	10	24	41	
All animals	3209	614	323	287	244	366	

*A plus sign means that more errors were made during the last half of the series than during the first half, a minus sign indicates the reverse relationship, and an equal sign shows that the number of errors was the same in both halves.

for the purpose of determining the effect of quantitative variations of the food incentive on performance

The data show that an increase in amount of incentive used consistently increased the delay limits. Decrease in amount of incentive always resulted in lower limits.

The amount of incentive affected not only response within a given trial, preceding ingestion of the reward, but produced also a general perseverative effect on subsequent responses, raising or lowering efficiency of performance according to the relative size of the incentive.

The "efficiency index" of the incentive, that is, the quantitative relation between amount of incentive and delay limits, is discussed

After preliminary adaptation to the situation, mere practice did not increase delay limits The number of trials given in succession likewise seemed to have no influence

More errors were made in the second half of each series than during the first half, regardless of the length of the series

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L'INFLUENCE DE LA QUANTITÉ DU STIMULANT SUR LE RENDEMENT DES CHIMPANZÉS AVEC DES RÉPONSES RETARDÉES

(Résumé)

Dan cette étude il s'agit des effets généraux et spécifiques des variations quantitatives de la nourriture comme stimulant sur le rendement de quatre jeunes chimpanzés avec des réponses retardées

En employant une quantité donnée de récompense, on a entrainé chaque sujet à choisir l'une de deux boîtes de nourriture dans laquelle il avait vu placer de la nourriture par l'expérimentateur L'intervalle de temps entre la mise de nourriture dans la boîte et l'occasion de la réponse a été systématiquement augmenté jusqu'à ce que l'on avait atteint la limite de la retardation

Une augmentation de la quantité de la récompense a donné conséquemment comme resultat une augmentation de la durée où le sujet a pu répondre comme il faut La décroissance de la quantité de la récompense a produit l'effet contraire.

Outre l'effet sur l'exactitude de la réponse qui précède la vraie ingestion de la récompense, la quantité du stimulant produit un effet général de persévération sur les réponses subséquentes Après qu'un animal aura montré un rendement réussi à de longs intervalles de retardation sous la condition d'une grande récompense, sa limite de retardation sera plus élevée qu'auparavant. On montre que les effets de l'exercise seuls ne peuvent expliquer cet effet. Quand on entremêle des épreuves à grande récompense avec des épreuves à petite récompense, on a comme résultat un meilleur rendement avec la petite récompense que l'on ne peut avoir quand la série se compose entièrement d'épreuves petite recompense

Nissen et Elder

DER EINFLUSS DER MENGE DES ANSPORNES AUF DIE VERZÖGERTE REAKTIONSLEISTUNGEN BEI SCHIMPANSEN

(Referat)

Dieses Studium beschatigt sich mit den allgemeinen und besonderen Wirkungen der quantitativen Veranderungen des Futteranspornes auf die verzogerte Reaktionsleistungen von vier jungen Schimpansen

Beim Gebrauch einer bestimmten Menge Futter als Belohnung wurde jedes Tier trainiert, einen von zwei Futterkasten zu wahlen, in den es den Vl das Futter hineinstecken sah. Der Zeitraum zwischen der Ladung des Kastens und der Gelegenheit zur Reagierung wurde systematisch vergrossert, bis die Grenze der Verzogerung erreicht wurde.

Die fortdaurende Vermehrung der Menge der Belohnung ergab eine Vermehrung der Zeitdauer, die bei jedem Tier zum richtigen Reagieren notig war Die Verminderung der Belohnung hatte die entgegengesetzte Wirkung.

Ausser dem Einfluss auf die Genauigkeit der Reaktion vor der eigentlichen Einnahme der Belohnung erzeugt die Menge des Anspornes eine allgemeine Beharrlichkeitswirkung auf nachfolgende Reaktionen Nachdem das Tier die Leistung erfolgreich uber lange verzogerte Zeitabstande unter der Bedingung einer grossen Belohnung ausgefuhrt hat, wird seine Verzogerungsgrenze mit einer kleinen Belohnung hoher sein, als sie vorher war Es zeigte sich, dass die Übungswirkungen allein diese Wirkung nicht erklaren konnen. Die Einmischung von grossen Belohnungen mit kleinen Belohnungen ergibt eine bessere Leistung mit der kleinen Belohnung, als es moglich ware, wenn die Reihe ganz aus kleinen Belohnungen bestunde

Nissen und Elder

SECOND YEAR DEVELOPMENT OF A RHESUS MONKEY *(Macaca mulatta)* REARED IN ISOLATION DURING THE FIRST EIGHTEEN MONTHS*[1]

From the Laboratory of Comparative Psychology, Columbia University

JOHN P FOLEY, JR.

The present paper represents a continuation of a previously reported study of the development of the rhesus monkey *(Macaca mulatta)*, and deals with the second postnatal year, the first half of which was spent in continued isolation, and the second half in contact with other members of the colony The need for such naturalistic and observational studies of the development of various primate forms needs no verbal justification A detailed study of the ontogeny or developmental continuum of such an organism serves as an essential background for related investigations of a more experimentally controlled nature. The interpretation of the behavior of animals in various experimental or laboratory situations can be legitimately made only in terms of its larger genetic configuration or meaning—the reactional biography of the organism (cf. 5, pp 39-41) Yerkes (41) has admirably stated the need for standardized primates, particularly of the anthropoid type, showing the many risks and disadvantages of using animals whose age or developmental status, sexual condition, disease history, and experience are unknown. Nissen (24) has pointed out, for example, how many of Kohler's *Umwage* and instrumentation situations (20) might readily be explained in terms of behavior mechanisms acquired and frequently executed in the natural habitat of the chimpanzee rather than in terms of "insight" or some other vague and highly complex mental process.

Not only is an understanding of the development of general

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[1]Acknowledgement is gratefully made to Dr C G Hartman of the Department of Embryology, Carnegie Institution of Washington, Baltimore, Maryland, for the donation of the subject of known parentage and gestation age, and to Dr C J Warden, of the Laboratory of Comparative Psychology, where the investigation was carried out

modes of primate response essential to interpretation of experimental data, but it likewise enables the investigator to formulate a problem more in accord with the naturalistic behavior systems of the animal. Thus the elaborate and highly controlled experimental investigation must take into consideration a wide variety of factors specific to the organism to be utilized, such as dominant receptor and reactor systems, dietary (especially maximal and minimal motivating conditions), general and specific rhythms and physiological conditions, and, above all, previous life history Nissen (24, p. 4) has pointed out that "we should never be able to posit limits for infra-human capacities without knowing how these creatures act in an environment which, so far as we can know, may be infinitely more favorable for the development and expression of such capacities than is a laboratory setting."

The recent foundation and growth of institutions for the study of primate behavioral development both in laboratory and field situations, such as is fittingly exemplified by the tripartite division of the Yale Laboratories of Psychobiology as described by Yerkes (39), argue for the importance of the parallel growth of both supplementary methods of approach. It should be pointed out, however, that so-called laboratory or experimental and field or observational investigations are not antagonistic, opposite, mutually exclusive, or intrinsically different, but differ in the relative amount of control imposed upon the organism-in-environment situation. Thus in the average field study no extraneous control whatsoever is imposed either upon the organism or upon its stimulating conditions, direct observations being made of the various reactions of the animal under such naturalistic conditions. In the laboratory experiment, however, various artificial restrictions are utilized, such as *a priori* selection of a given response or series of responses for experimental study, elimination of certain stimulational cues, enhancement of particular motivating conditions, etc.

The necessity for complete data on the reactional biography of the individual organism, and in some cases control over stimulating conditions from birth onward, is now quite generally recognized. In comparing the behavior of various primate forms, serious considerations should be given to the wide differences in both anatomico-physiological and psychologico-behavioral development from primate to primate (cf. 5) As Kellogg (18) has further pointed out,

comparative psychology frequently fails to recognize the tremendous rôle played by environmental influence upon captive wild animals both prior and subsequent to their laboratory debut Any one who has had first-hand acquaintance with the usual capture and transportation conditions of wild animals will often wonder how such animals have ever been successfully used for behavior research. Any such wild animal who adapts to a strict laboratory routine has exhibited a far greater degree of behavioral modifiability than is required or produced by the average experiment.

The writer has elsewhere (5) reviewed the literature dealing with the developmental aspects of the early behavior of the *Macaca mulatta,* and has discussed both the implications and possibilities of such research That such studies are as yet surprisingly few indicates the complex of difficulties attendant upon any undertaking of this nature, as well as the past failure to recognize the various potentialities, both theoretical and practical, of this research. It is satisfying to note, however, that psychological and psychobiological research on the development of infra-human primates is increasing both in amount and in span of undertaking, and the resulting material is rapidly becoming data for a more inclusive science of comparative or evolutionary psychology (cf 6).

Problem

The present article reports fragmentary data on the second year development of a rhesus monkey *(Macaca mulatta),* reared for one and one-half years in isolation from its mother and other members of the species, and subsequently housed with other monkeys both of a similar and different species. The subject, a male, was subsequently given the name "Kras" The animal was born in the Laboratories of the Department of Embryology, Carnegie Institution of Washington, Baltimore, Maryland, being the son of No. 106 of that primate colony Birth occurred in the early morning of October 9, 1932, after a gestation period of 167 days The infant was forcibly taken from the mother on the morning of October 12, three days after birth, and transferred by automobile directly to New York, where it has since remained in the Laboratory of Comparative Psychology of Columbia University

Throughout the subsequent two-year period, there was no attempt at tuition, nor was the animal reared as a pet Contact with

humans and other animals was kept at a minimum during the first one and one-half years, involving only the feeding and observational periods, after which the subject was housed with other monkeys and allowed to adapt and react with a minimum of external interference. As previously stated (5), it should be emphasized that the task was attempted as an exploratory investigation or pioneer study, the object being to test the feasibility of rearing an infant monkey in isolation, with the attending problems of diet, housing, and general care, and all other purposes were subordinated to this primary aim. Observations are thus often brief and fragmentary rather than final and conclusive, and this is all the more true of the second year of development, since time for observation was limited It was deemed worth while to present a few of the most outstanding data, however sketchy and incomplete, as a further chapter in the reactional biography of the subject. The continued physical and behavioral development of the subject testifies to the realization of the primary purpose of the project, and it is hoped that the infant *Macaca mulatta* will be increasingly utilized in future comparative psychological research.

The first year development has been described in detail in a previous report (5), and familiarity with the material therein presented is necessary in order to grasp the relative significance and larger *Gestalt* of the present data. In order to avoid duplication as much as possible, many accessory data have been omitted in the present paper, and it is hoped that the reader will correctly regard the data reported in the following sections as as a mere continuation of the previously reported investigation. As in the previous report, not only is the gradual development of various behavior segments described, but *an attempt is made to correlate the acquisition of the various reaction systems with the particular stimulating circumstances which produced them.* The sudden change of the subject from an experimentally imposed situation of complete isolation to one of intimate association with other monkeys throws additional light upon the nature of certain underlying behavior mechanisms.

HABITAT

Having been periodically transferred to increasingly larger quarters at various times throughout the first year (cf. 5, pp. 51-52), the infant macaque, then over five months old, was finally housed

in a standard monkey cage in an isolated part of the primate room. This cage was 28 x 35½ x 34 inches, with a front door of 1-inch diamond mesh, and with a wooden shelf 18 inches above the floor. A ¼-inch galvanized grill floor was situated above the sawdust floor pan Here the animal was reared in continued isolation throughout the remainder of the first one and one-half years, at which time, on April 9, 1934, it was transferred to a similar cage within the primate arena This arena is composed of two double rows of cages one on either side, facing each other, the ends and top of the intervening space being screened in with 1-inch diamond mesh so as to form a central enclosure or runway 6 feet wide, 13 feet long, and 7 feet high Here the subject could be daily allowed to exercise and play, both alone and with other selected animals. The daily 30-minute period of Sunlamp stimulation was continued throughout the second year.

Dietary

The standardized Columbia weekly feeding schedule for monkeys, begun at the eight month (cf. 5, pp 52-54), was continued throughout the second year (cf below) As before, a cod liver oil preparation was also employed daily, made from Squibb's Adex Tablets, with Viosterol, 10 D, powdered and mixed with Lactophos (bone meal) The daily evening ration of banana was partially slit longitudinally and a small amount of this powder sprinkled inside, thereby insuring a certain constancy and control in the amount taken, with a minimum of trouble and inconvenience to both investigator and animal. This diet proved most satisfactory, as is testified by the steady increase in weight (cf. Results) and by the fact that severe diarrhea or other pathological symptomatology was not evidenced at any time throughout the two years

Standardized Columbia Weekly Feeding Schedule for Monkeys

	8 00 A M.	1.00 P M	6 00 P M
Monday	Milk & Eggs	Boiled rice, Celery	Banana
Tuesday	Milk & Eggs	Boiled potato, Beet	Banana
Wednesday	Milk & Eggs	Wholewheat bread, Lettuce	Banana
Thursday	Milk & Eggs	Boiled rice, Spinach	Banana
Friday	Milk & Eggs	Wholewheat bread, Celery	Banana
Saturday	Milk & Eggs	Boiled sweet potato, Carrot	Banana
Sunday	Milk & Eggs	Wholewheat bread, Lettuce	Banana

Also small amounts of apple, orange, raisin, sunflower seed, and peanuts

Discussion of Results

In accordance with the general plan utilized in the previous study (5), the more outstanding observations of the subject's second year of reactional development are presented in three sections: (1) Physical Development, (2) Sensorimotor and Simple Behavioral Development, and (3) Complex Behavioral Development. Again may we point out that such a division is quite arbitrary, but serves as a convenient schema for classifying the oftentimes scattered and fragmentary observations. *As previously stated (cf. above), no* attempt is made to portray the complete behavior repertoire of the subject, but rather to present certain of the more interesting and genetically significant data.

1. *Physical Development.* The average monthly weight of the subject throughout the second year is shown numerically in Table 1 and graphically in Figure 1. Measurements were taken weekly in all but two cases (periods 23 and 24), for which three and two weights were recorded respectively. The figures presented are the averages of the readings taken for each successive 28-day period.

Inspection of these data will show that the subject continued to increase rapidly in weight during the second postnatal year, although the amount or degree of such increase became gradually diminished (cf. 5, Table 2 and Plate I, pp 55-56). The subject weighed 422 grams, or 14.9 ounces, at birth (Oct. 4, 1932); 1508 grams,[2] or 53.1 ounces, at 1 year of age (Oct. 4, 1933); and 2013 grams, or approximately 71 ounces, at the age of 2 years

TABLE 1
Average Monthly Weight During the Second Year

Age*	Average weight (grams)	Age*	Average weight (grams)
14	1544	21	1875
15	1606	22	1909
16	1631	23	1937
17	1698	24	1964
18	1753	25	1971
19	1789	26	2003
20	1832		

*Successive 28-day periods

[2]Weight at age of 52 weeks (5, p 55, Table 2) misprinted as 1580 grams; should read 1508 grams.

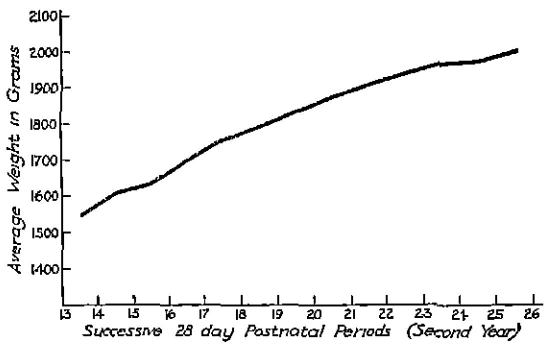

FIGURE 1

AVERAGE MONTHLY WEIGHT DURING THE SECOND YEAR

(Oct. 4, 1934). These figures are slightly lower but in general corroborate those given by Schultz (28), who has reported tentative average weights of 1646 grams (8 cases) and 2450 grams (6 cases) at the end of the first and second years, respectively. Thus during the first year the present subject showed an increase of 1083 grams in body weight, whereas only 508 grams were gained during the second year, less than half of the first year growth. Since the data are for 28-day periods, all minor fluctuations are necessarily omitted, although inspection of the original weekly (and on a few occasions, daily) measurements yields the fact that with increasing age such fluctuations become less apparent, relative to the weight of the animal.

The disproportionately large head and ears and small hind quarters, markedly present during the earliest postnatal days, gradually disappeared, so that by the end of the second year Kras had definitely assumed the bodily proportions of the adult *Macaca mulatta* (cf Schultz, 28) The hair, straight and medium in texture, has attained the varied length, density, and brownish color of the typical macaque, and is characteristically distributed over the entire body surface with the exception of the upper eyelids, nipples, ischial callosities, palms, soles, and terminal phalanges (cf. 15). The facial wrinkles, gradually decreasing from birth in both number and degree, have completely disappeared The testicles remain undescended, clearly visible in the canal some distance above the scrotum

2. *Sensorimotor and Simple Behavioral Development.* The sensorimotor development of the infant *Macaca mulatta* has been described in a preceding connection (5) as being virtually complete by the middle of the second postnatal week, and hence need not be discussed here. Subsequent practice, however, especially in activities involving motor adjustments, resulted in finer differentiation of the specific behavior segments or reaction components, as well as an increasingly wider variety of such intricate responses to an increasingly larger number of stimulus objects and events. Not only did new objects acquire additional stimulus functions or meanings, but many of the responses formerly made to certain stimuli were lost, or rather, replaced by other patterns of reaction

Sleeping, so frequent during the earliest days, was seldom noted in the daytime during the second year. The specific overt pattern remained largely unchanged from approximately the second month, consisting in sleeping with the body bent forward, the legs flexed and drawn up under the body, and the arms extended forward and outward to form a cushion for the head.

Yawning, not observed during the first year, was subsequently noted on several occasions. The mouth was partially opened and the lips drawn back on either side of the mouth, exposing the teeth This is a more or less typical reaction pattern of the macaque, and differs from yawning in the typical human animal in that in the latter subject the mouth is usually opened wide and the lips are drawn taut more in the vertical than in the horizontal plane. *Coughing* and *choking* were seldom observed, this decrease in frequency probably being due to more efficient use of the masticatory and deglutitory mechanisms *Sneezing* was not observed during the second year, nor could it be elicited by tickling the inner nostrils with a horse-hair point. The nose and entire facial region became wrinkled upon such stimulation, but no sneezing resulted. The writer would not wish to conclude that the mechanism was absent, however, since more adequate stimulation of the internal membranes might very likely elicit the reaction As would be expected, the *lid reflex* or *rapid winking response to a non-visual stimulus* showed no observable change.

Responses which we have characterized as *mouthing, nuzzling, biting* (non-masticatory), and *oral exploration,* commonly exhibited by the infant macaque in the earliest days, had practically disap-

peared by the fifteenth month Only on occasions of extreme emotional stimulation and excitement did Kras resort to such behavior (cf. below). Thus these biting or mouthing responses were originally the precursors of modified *sucking reactions* (cf 5, pp 67, 80), which in turn partially gave way and were replaced in many cases by other more adaptive forms of behavior. As in the case of their predecessors, the sucking reactions remained relevant only to certain (i e., liquid food) situations, and were no longer elicited by a wide variety of stimulation

The early forms of *crying* or *vociferation* persisted with certain modifications of patterning, and the stimulus conditions for such behavior became widely varied. This behavior, with special reference to certain acquired vocal and stimulational characteristics, will be discussed in the following section on "Complex Behavioral Development"

The *scratch reflex* or *scratching reaction* was infrequently noted, having disappeared as a common occurrence as early as the fourth week (cf. 5, p. 68). The *righting reflex* continued to be exhibited whenever the animal was released ventral side up, and was executed with a minimum of useless and uncoordinated movements The *grasping reflex, clutching* or *clinging response,* involving the more complex reactions of *contact seeking* and the *seeking of bodily support,* the most outstanding and persistent behavior patterns during the early stages of behavioral development, gradually diminished both in frequency and in degree of manifestation. By the end of the second year, such reactions were observed only in cases of severe emotional excitement (cf below). Whereas it was once almost impossible to force the infant to relinquish his grasp on a suspended horizontal bar (5, pp. 69-72), such reactions were but occasionally observed at one year of age, and by the end of the second year the subject would not cling to the bar under any conditions whatsoever, but would immediately drop to the floor These data are analogous to those reported by Watson, Gesell, and others for the human infant. As previously pointed out (5), this transition in grasping or clinging behavior was gradual, and its decreasing manifestation was correlated with the acquisition and development of locomotion and other complex sensorimotor coordinations. The above statements are made with reference to what may properly be termed the grasping or clinging reflex, manifested whenever the usual means of support was removed (e g , clinging to a suspended

bar in mid-air), and do not refer to cases in which the monkey grasped or clung to a desired object, such as a piece of food. The grasping response *per se* undoubtedly remained intact, although it was no longer elicited by stimulation involving loss of support, the entire picture being further complicated by the animal's wide range of adaptive, substitute, or alternative reactions.

By the end of the second year, *locomotor abilities,* including *walking, running, jumping, climbing,* and related activities, had reached a state of perfected coordination and efficiency equal to that of the typical adult macaque This development was at first observedly retarded by the artificial isolation and attendant restriction of stimulation and response experimentally imposed upon the subject for the first one and one-half years, although the subsequent one-half year period of association with other members of the species was sufficient to make up for the minor initial deficiency. There was, however, a tendency for the subject to rear up, stand, and walk for short distances on his hind feet alone more often than in the average macaque. This observation was made as early as the beginning of the fourth month (5, p. 73), and continued to hold for subsequent periods, although tuition in the trait was never given.

Likewise, the *tendency to climb or orient upward* was not observed during the second year. As pointed out in the article dealing with first year development (5, p. 74), *upward climbing reactions to the vertical stick and upward orientation on the elevated platform,* markedly present immediately subsequent to birth, tended to disappear after the infant had learned to walk and make a wide variety of substitute adaptive reactions. This finding, a corroboration of the results of Tinklepaugh and Hartman (32), is closely related to the observed disappearance of the *grasping reflex* (cf above), since the upward climbing reaction is obviously complicated by the basic grasping, clutching, and contact-seeking responses, by emotional factors, and in fact by the developmental status of the entire behavior repertoire of the subject

Play behavior, consisting of *running, jumping, climbing,* and *leaping upon* and *seizing* objects, with attendant *vocalization,* showed a pronounced increase immediately after Kras was housed in close proximity to other monkeys. When let out into the central arena or runway, he would run from side to side, climbing up the screening at the end of the enclosure, only to jump to the floor again

He would often climb up on the heavy diamond mesh forming the door of another animal's cage, and would frequently swing back and forth on the door of his own cage, alternately opening and closing it The last few weeks of the second year, however, seemed to show a slight decrease in general amount of spontaneous play activity This may have been a mere artifact, or may possibly be a precursor of a less active existence. Carpenter (4, p. 79 ff) has recently observed that the amount of play activity shown by young howling monkeys in their native habitat "increases until the juvenile 1 stage, and then there is a rather sharp decline to a minimum of play in adult animals." It is also interesting to note that rarely did the present subject, during the course of his climbing and random play activities, invert his head or body Descents from a height were almost invariably made either in the human fashion, hind feet first, or by jumping Additional relevant material regarding play activities, especially as influenced by social stimulation, will be presented in the following section

Too much emphasis cannot be placed upon the remarkable degree of *sensorimotor coordination* attained by the two-year-old subject. Whereas during the early days, "misjudged distances were the rule rather than the exception" (5, p 76), later reactions were perfected and executed with such precision, speed and timing, that they often escaped human observation Especially outstanding was behavior predominantly characterized by *prehension* and *manipulation* of stimulus objects. Use of the pedal extremities, however, was definitely inferior to that exhibited by the typical macaque. This deficiency may with a high degree of probability be attributed to the experimentally imposed isolation, with lack of stimulation and practice conducive toward the development of such behavior

Use of the cheek pouches, first noticed at 107 days of age (5, pp. 76, 81), became a common behavior trait, not unlike that of the average rhesus monkey This topic will be discussed in connection with feeding behavior in the following section.

3 *Complex Behavioral Development* During the second year, *feeding behavior,* including biting, chewing, and swallowing, was observed only in situations wherein food was available, showing that differentiation with respect to such stimuli had been satisfactorily accomplished This behavior was in marked contrast to the early tendency to bite immediately at any object held within the

infant's visual field (5, pp. 78-79). If food was presented which had never before been experienced, Kras would seize and convey it to the nose for olfactory inspection, before putting it in his mouth. When satiated, the subject no longer made the once characteristic thrusting and slapping movements of the arms and hands, but left the food at once and reacted to other stimuli. If the food were removed before satiation had occurred, however, the same type of violent emotional response was made as formerly, involving puckering of the mouth, vociferation, frequent thumbsucking, plus a new addition, jumping up and down.

Liquid food was taken from the pan by the combined process of *suction* and *lapping* movements of the tongue. The repeated *grasping* reaction with the hands and fingers while feeding, involving alternate opening and closing of the hands and digits, which at first was made with such frequency but which disappeared by the tenth postnatal week (5, pp. 80-81), was never again observed in a food-taking situation, although such behavior did reappear during violent emotional stress. In the natural, undisturbed mother-infant situation, these early clutching reactions, in so far as they are elicited by and directed toward the ventral furry surface of the supporting mother (16, 31, 32), undoubtedly have some adaptive value, and such behavior was "carried over" and exhibited by the infant Kras in response to feeding situations after experimental isolation from the mother, the diminuation and subsequent disappearance of such reactions taking place in conformity with a principle not unlike that of experimental extinction.

The *cheek pouches* were frequently used for storage of food, especially if the subject was fed in the immediate presence of other monkeys. Food could thus be hurriedly taken, retained, and subsequently eaten over a period of time, being pushed out into the mouth cavity with the hands or shoulder blades. *Food preferences* were also exhibited, milk, orange juice, and mush or gruel being most readily taken throughout the second year. It is of importance to note that these liquid or semi-liquid foods constituted the exclusive diet up to the age of 5 months (cf. 5, p. 53), and maintained their preferential value from the beginning. Apple, raisin, peanuts, and sunflower seed, having the highest motivating value for most of the monkeys in the Columbia colony, elicited secondary preferential reactions in the present subject. In fact it might be said that in

general the preference was inversely proportional to the dryness and solidity of the food. Banana was relatively well liked. Kras did not actually peel it, however, as does the typical monkey, even when the peeling is later to be eaten. This lack of specific differential response to peeling and internal fruit characterized the subject's behavior from the first, as was pointed out in the previous report (5, p 82), and certainly cannot be attributed to lack of requisite sensorimotor mechanisms. Only occasionally, when the relatively harder peeling offered more resistance to the teeth, did Kras push back the peeling a few millimeters with his thumb. The succeeding bite, however, consumed both peeling and enclosed fruit.

No *coprophagous behavior* was observed at any time. Whereas on a few occasions during the first year the infant manually and olfactorily examined the feces, although never tasting or eating them, he seemingly learned to avoid them entirely, for even such cursory interest and examination was never noted during the second year period.

Vocalization continued to be less frequent than in the average macaque of the same age The repertoire remained practically the same as that previously reported for the thirteenth and succeeding weeks (5, p 84), with the single addition of what may be termed a "hunger-anticipation cry," which appeared during the latter part of the nineteenth month, after the subject had been housed for 2-3 weeks in close proximity to the other monkeys In general, the following four types of cries could be distinguished by the end of the second year

1 *"Play cry,"* consisting of a clear, shrill, and high-pitched cry made with the lips pursed and rounded A given cry somewhat resembled the sound of the double vowel in the word "food," although slightly slurred, and increased and then decreased in pitch

2 *"Fear-Pain cry,"* consisting of a scream of rapidly varying pitches, made with the mouth open and the entire face wrinkled and distorted

3 *"Food-Contentment cry,"* consisting of a soft, short, guttural, and slightly hoarse noise, often accompanying eating, gentle stroking or handling, or attainment of contact or support after emotional stimulation, and often associated with rapid opening and closing of the lips ("mouthing response")

4 *"Hunger-Anticipation cry,"* consisting of a clear, falsetto cry of descending pitch, made with the lips in their normal position and the mouth partially open

The difficulty and necessary artificiality of reducing the complex vocal behavior of the *Macaca mulatta* to a simple classification cannot be overemphasized. If the restrictions and limitations of the classification are kept in mind, however, it does seem both empirically justifiable and profitable to isolate these major types of vocal behavior, and to consider other cries as modifications of the above four. The repertoire of the present subject at two years of age seems to have been fully as complete as that of the other, older monkeys in the Columbia colony. The "food-contentment cry" was more fully developed and frequently elicited than in the other macaques. With respect to the fourth or "hunger-anticipation cry," it is interesting to note that it was acquired in the most exact detail from the other monkeys At no time was it heard during the period of isolation, prior to the nineteenth month. Later, however, when the experimenter would enter the laboratory in the morning just before feeding time, the sound of his footsteps and the opening door would immediately elicit the cry from Kras and the entire colony Similarly, the closing of the ice-box door caused the same vocal reaction, which did not occur at the closing of cabinet and other doors not associated with or conditioned to food-taking situations.

Prehension, manipulation, and *eye-hand coordination* have been discussed in the preceding section *Handedness* continued to be non-preferential, the subject being completely ambidextrous with respect to frequency and efficiency of manual prehension and manipulation. *Play behavior* has also been discussed at length above. It might here be added that, at approximately the nineteenth month, Kras developed a more or less indirect, circuitous, or "stalking" type of play activity which was not exhibited prior to his entry into close association with the other monkeys at 18 months of age (cf 5, p 75) Although the account of the development of their non-isolated rhesus monkey does not go beyond the fifteenth week, Lashley and Watson (22, pp. 137-138) describe the play of their subject as "beginning as simple thrusting out of his hands against his mother," and state that "it developed rapidly into the more complex stalking of various objects in the cage." They also observed that "the stalking play was at first directed toward all conspicuous objects in the cage, but as the baby learned to eat solid food his attention became more and more directed toward this, and his play activities to center around it." Thus the present finding

would be expected in the light of Lashley and Watson's data, i.e., the absence of such activities during an extended period of complete isolation, and the rapid acquisition of such behavior when the animal was placed in a more competitive situation wherein such reactions were frequently practiced by all concerned.

This noticeable increase in *play behavior* has been described in the previous section dealing with "Sensorimotor and Simple Behavioral Development." Such an increase may be characterized as a gradual change from the original self-composed or more nearly "introverted" type of play behavior toward a more objective or "extroverted" mode of response. In this connection, Lashley and Watson (22, p. 138) make the following statement in regard to their infant macaque:

> "Self imitation," so marked during certain stages of the human infant, was almost entirely lacking. The few actions which might be so interpreted were those of climbing and leaping, with evident enjoyment of the activity itself. . . . In most of his play, however, his interest seemed to be centered in external objects rather than in the movements themselves.

It seems clear, however, that in the present case at least, this external reference was slowly acquired during the development process, and that the acquisition of such behavior, undoubtedly retarded by the experimentally imposed isolation, was rapidly enhanced by placing the monkey with other animals in a more extensive milieu of stimulating conditions.

Little variation in the patterned *emotional behavior* of the subject took place during the second year, although the nature and range of stimuli eliciting a given emotional response were considerably altered. The greatest change occurred in connection with the *"fear reaction,"* whose pattern has been previously described (5, p. 86). This response pattern, violently elicited (postnatal) by removal of contact or support but not originally elicited by loud sounds, came, by the end of the second year, to be evoked by certain loud and novel sounds, such as the bark of a dog or the sound of breaking glass, and at the same time disappeared in response to stimulation by removal of support. The latter disappearance may be easily understood in terms of the acquisition of other modes of adaptation to the once "fear-evoking" removal of support, and might have been predicted on the grounds of behavioral development. Similarly, the later potency of certain loud and novel sounds as instigators of

"fear" behavior may quite likely have been the result of conditioning received subsequent to the eighteenth month The *"rage"* or *"anger reaction"* (cf. 5, p 88) continued to be evoked by hampering or restraining the animal's movements, being accompanied by thumb-sucking and, on very rare occasions, by what we have termed the "fear-pain cry." The *"love reaction"* also showed but little change (5, p 88), and was made on occasions immediately following extreme fright or in response to certain other monkeys or to the experimenter (never to strangers). At such times the "food-contentment cry" was commonly made In general, it may be stated that during the first two postnatal years emotional behavior became gradually less intense with increasing morphological and behavioral development.

Clinging behavior, originally elicited in response to the experimenter's hand, so that the latter literally became a *fetish* for the animal, although at first without sexual significance (5, p. 91), took on the function of a sexual stimulus toward the beginning of the second year, although the exact date cannot be accurately given. The original traces of this behavior were greatly reinforced subsequent to the eighteenth month, at which time the infant's curve of sexual behavior rose with a rapidity great enough to be characterized as "insight" by the typical Gestaltist. A more detailed account of sexual behavior will be presented below.

Emotional fits or *tantrums* continued to result from forcibly depriving the monkey of a play or food object (cf. 5, p 91). Similar emotional responses ensued if such a desired object was given to another monkey, and will be discussed below in connection with the more complex trait of "jealousy." If at any time a small leather belt, similar to that worn by the other members of the colony, was placed around his waist (5, p 92), Kras immediately showed the characteristic emotional grasping behavior, pulling at the belt, clutching himself, swaying or oscillating back and forth, sucking his thumb, and crying, until the belt was removed At such times Kras would also utter the "fear-pain cry," rear up on his hind legs and go around in circles, often striking his head and body against objects in the room in his frenzy to remove the obstacle.

It is of interest to note that at no time did Kras, regardless of his emotional state, make the slightest attempt to bite the writer, although on rare occasions he would playfully bite a stranger at

the slightest provocation Nor would he utter a cry if hurt or painfully stimulated by the experimenter. The prick of a needle would elicit only contortion of the face and sporadic escape movements similar to those made if he were forcibly restrained. The "fear-pain cry" thus rarely denoted pain *per se,* but more often anger or other antagonism resulting from such stimulation

It will be recalled from the original article on first year development (5, p. 92) that *oscillating* or *swaying* movements were present from the third postnatal day, being "usually made in an emergency and highly emotional situation" The exact pattern of response involved either placement of the hands and forearms on the floor directly in front of the body or grasping the thighs or hind legs, the total body maintaining the sitting posture, and the making of rapid and rhythmic movements, the body being alternately raised and lowered, i.e., swayed back and forth. In the original report, the writer mentioned unpublished observations by Nissen on the occurrence of such behavior in the chimpanzee, as well as the previously unreported occurrence of similar reactions in the isolated infant macaque of Engle Although such activity is superficially similar to that often occurring in sexually stimulating situations, it should not be confused with attempted copulatory behavior, since its ontogenetic origin, particular stimulational antecedents, and component details are entirely different in character.

The *"mouthing and tongue response,"* present from the seventy-first day, and involving rapid opening and closing of the mouth or lips and corresponding thrusting and withdrawing movements of the tongue, and often occurring in conjunction with the "food-contentment cry," was also frequently observed during the second year As formerly, the response was often made before or after feeding or when the monkey was stroked or petted following extreme fright (cf 5, p. 92) Subsequent to the twentieth month, however, the response was additionally observed in sexually stimulating situations in which the subject was attempting to copulate with some other monkey or with the experimenter's arm. The sexual significance of such a "mouthing response" prior to copulation has been recently reported by Carpenter (4, p 82 ff.) in his field study of the howler monkey In describing this "provocative" behavior of the howler in its native habitat, Carpenter concludes "The behavioral aspects preliminary to copulation are the rhythmic tongue move-

ments, provocative posturing, and exploratory behavior." Such reactions were not observed in other, non-sexual situations, as in the case of the present subject, *although such a deficiency might be due to inadequate opportunities for observation or to the lack of adequate stimulation such as that received by the present subject*

Thumbsucking, another emotional accompaniment, also persisted throughout the second year, although the total amount of time spent in such activity decreased, owing to the larger and more varied repertoire of substitute behavior The great toe of the left hind foot continued to be favored (cf 5, pp 92-93), and as a result became greatly enlarged, the discrepancy in size between the great toes of the two feet being of the ratio of 2 to 3 The act was so firmly fixed that at times Kras would traverse the length of his cage on three legs, the great toe of the fourth remaining "contentedly" in his mouth

Several cases of interesting *mannerisms* and *"habit residuals"* may be parenthetically noted The upward motion of the hind foot as if to place the great toe in the mouth was cited in the previous report (5, p 93). In the light of the recent work of Hull, it would be highly informative to know if such a response were "anticipatory" and hence connected with any salivary disturbance. The disappearance of the repeated grasping movements formerly made while drinking (cf above) illustrates the abandonment of another such residual. A further example of habit residual is illustrated by frequent clutching of the right eyebrow with the corresponding hand. No foreign particle was detected in the eye itself, and the mannerism was probably due to the extremely long and projecting eyebrows which once undoubtedly partially obstructed the infant's visual field. The reaching response persisted, however, although the longer eyebrows were carefully cut.

The *sexual behavior* of the present subject was particularly informative, and deserves separate consideration quite apart from its emotional aspect. The experimentally imposed conditions under which the animal lived and developed showed a remarkably high correlation with the sexual behavior patterns exhibited from time to time in the course of reactional development. The following statement was made in the report covering the first year development:

> As would be expected from other studies on isolated animals, the sexual behavior of the present subject was practically nil. The swaying movements and mouthing reactions, although

> superficially resembling modifications of sexual behavior, had *no such actual significance. The testes did not descend during* the first year. , nor was erection observed during this period, although it has been subsequently noted In striking contrast, Lashley and Watson . observed such a reaction on the sixty-first day (5, p. 93)

As pointed out above, the testicles remained undescended during the second year. Erection was first noted during the fifty-ninth week, and continued infrequently to appear, although prior to the eighteenth month it was rarely accompanied by other overt behavior. Occasionally Kras would touch the erected organ, but such manual manipulation was by no means more frequent than similar behavior in response to other relatively erogenous areas of the face and extremities Thus there was a minimum of explicit sexual behavior during the period of isolation, and the relatively late incidence of the then unconditioned and more or less strictly biological act of erection, in contrast to the data of Lashley and Watson, further substantiates this fact The behavior of the subject, both when alone and when placed with other monkeys for a short observational period, was consistently *non-sexual*

After having been permitted closer association with other monkeys from the age of 18 months, however, Kras began to exhibit such sexual behavior The earliest reactions consisted of olfactorily exploring the body of the other monkey, clutching some part of the animal's body, usually the leg or back, and making a few sporadic thrusting movements of the pelvis Erection was not always present on such occasions, and no preference was evidenced for female over male animals nor for the rhesus over the cebus or capuchin types. In fact such reactions were on a few occasions observed in response to a rag or other soft object By the end of the second year, the sexual behavior had become more or less localized with respect to the genital regions, and there was a general although by no means exclusive preference for female animals. The arm and hand of the experimenter continued to function as a sexual stimulus, as has been described above in connection with the "mouthing and tongue response" The following quotation from the laboratory notes for October 5, 1934 is a typical illustration of sexual behavior at the end of the second year in response to a very tame and good-natured female macaque, approximately 7½ years of age·

> When turned out with Bright Girl today, Kras played around in the arena for 4-5 minutes without apparently noticing her He finally approached and grasped her around the waist from the rear, after smelling the vaginal and anal regions several times. Erection appeared and, as she remained crouching on the floor, he strengthened his hold around her waist with both arms, and made the characteristic rhythmic thrusting movements of the pelvis, the tail curling up under the legs. Bright Girl remained passive, and the movements ceased within 10 seconds.

These data are in full accord with the findings of Hamilton (13, 14), Tinklepaugh (29), and Zuckerman (43) on monkeys, and other investigators on infraprimate mammals in regard to experimentally produced homosexuality and other sexual aberrations and the consequent general importance of stimulating circumstances in conditioning fundamental drives and action-tendencies. *The important thing, so far as the description of behavior is concerned, is not the constitution and relative strength of the so-called basic drives of the organism, but rather how such "drives" are conditioned, for it is only this historical or biographical factor which can adequately account for the specific strength and patterning of behavior.*

The *reactions of the subject to other animals* continued to be positive in all cases with the exception of certain monkeys who slapped and bit at Kras whenever he approached, and even in such cases definitely aggressive behavior was usually exhibited. The original clutching reaction (5, pp. 94-96) of course disappeared, just as it had in response to inanimate stimuli. Kras developed certain *preferences* and *aversions* for particular monkeys, however, and these led to the formation of *social groupings*, incipient stages of phenomena which have been described by Bingham (2), Carpenter (4), Nissen (24), Zuckerman (43), and others for infrahuman primates, and by Bühler, Gesell, Jones, and others too numerous to mention for the human child Thus, for example, Kras and Bright Girl constituted one such early social grouping, quite independent of sexual behavior They would climb around the cage and play together, even getting in and out of each other's cages If another caged monkey would exhibit anger and menacingly jump forward to the door of its cage, both Kras and Bright Girl would approach and try to seize or bite the monkey's hands through the cage door. This particular grouping was weakened, however, as a result of frequent attempted copulation on the part of Kras

Aggressiveness characterized the behavior of the subject throughout the second year. Behavior not dissimilar to that termed *jealousy* was also frequently exhibited. If food were given to another monkey, even to one for whom Kras had formed a positive attachment, he would often display a series of violent reactions, jump up and down, put his ears back against his head, and utter the "hunger-anticipation cry" followed immediately by the "fear-pain cry," and if these were to no avail, he would finally resort to thumbsucking On rare occasions he would become bold enough to dash up and try to snatch the food from the other monkey's hand, although he was usually briskly cuffed away, after which he would not dare to repeat the attempt for some time He would become quiet immediately if given food, making the "mouthing and tongue response" and uttering the "food-contentment cry"

Certain early *perceptual* reactions of the subject, occurring prior to experience with a particular object or class of objects, are not without interest. The evolution of the subject's *reaction to his mirror image* was described in the previous report (5, p 98) and showed little further change In fact it became increasingly difficult to get the animal to attend to a given stimulus object, since such a wide variety of stimuli and reaction-systems was continually competing for his attention On one occasion during the fifty-fourth week, however, Kras was seen suddenly to place his ears back and jump forcefully against a large pane of glass, in which he no doubt saw his reflected image The *lack of differential response to the peeling and fruit of a banana* has been discussed above in connection with feeding behavior At 16 month of age, the *response to ice* was first tested When a piece of ice was placed on the floor of his cage, he looked curiously at it, slapped at it, and then explored and finally seized it in both hands and jumped up onto the shelf of the cage He held the ice for approximately three minutes, licking it periodically and occasionally trying to bite it. Finally it was abandoned on the floor, although he returned and continued to play with it from time to time. Two further interesting observations on perceptual behavior during the first year were unfortunately omitted from the previous report. During the forty-fifth week, Kras was seen to *reach out and attempt to grab or manually manipulate smoke rings* accidentally blown by an observer Similarly, at approximately one year of age, he was observed to jump up into the laboratory sink and *endeavor*

to climb up a smoothly flowing stream of water The above examples of objectively inappropriate reactions, although sketchily drawn, illustrate certain stages in the development of perceptual adaptations, and are not without value for an empirical or behavioral theory of space and object perception. Such subtle conditionings which inevitably occur during the reactional biography of any organism can be profitably investigated only by means of a genetic approach. The work of Piaget and others on the acquisition of perceptual and conceptual reactions in the human child finds many counterparts in the field of animal behavior, and such a field offers unlimited opportunities for further research

Lastly, it may be stated that neither *auto-grooming* nor "social" or *inter-individual grooming* (cf. 5, pp 98-101) was exhibited by the present subject during the first two years of life. Whether such a behavioral deficiency was due to the absence of dirt and body parasites or whether it may be attributed to the lack of opportunity for the early acquisition of such a reaction pattern cannot be stated. The data nevertheless cast considerable doubt upon the hypothesis that grooming is an instinctive primate function or that it is dependent upon neural or neuro-muscular maturation

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LE DÉVELOPPEMENT PENDANT LA DEUXIEME ANNÉE D'UN SINGE RHÉSUS (*Macaca mulatta*) ÉLEVÉ DANS L'ISOLATION PENDANT LES PREMIERS DIX-HUIT MOIS

(Résumé)

Cette étude est une continuation d'une étude déjà rapportée, et décrit le développement pendant la deuxième année d'un singe rhésus (*Macaca mulatta*) élevé dans l'isolation complète de la mère et des autres membres de l'espèce pendant les premiers dix-huit mois, et subséquemment logé avec d'autres singes dans les quartiers généraux des primates du laboratoire

L'auteur appuie sur le besoin d'une connaissance détaillée de l'histoire psychogénétique spéciale ou biographie réactionnelle d'un animal expérimental quelconque employé dans la recherche du comportement. L'autre partie de l'article discute l'expérience elle-même, y compris la description du *problème, l'habitat,* le *régime,* et la *discussion des résultats* Quand possible, on rapporte les *données pertinentes* d'*autres investigations* On discute les résultats sous trois titres principaux, appuyant surtout sur le troisième

(1) le *développement physique*
(2) le *développement sensorimoteur et le développement simple du comportement*

(3) le *developpement complexe du comportement*
La dernière catégorie comprend la discussion du comportement de manger, la vocalisation, la préhension et la manipulation coordonnées, les activités du jeu, le comportement émotif, le sucement du pouce, les maniérismes, les réactions anormales et les restes des habitudes, le comportement sexuel, les réactions aux autres animaux, les groupements sociaux, les principaux traits de personnalité, le comportement perceptif et conceptif, et les soins de propreté

Non seulement on décrit le développement graduel de ce comportement, mais on essaie de corréler l'acquisition des divers systèmes de réaction avec les circonstances stimulantes spéciales qui les a produits Le changement soudain du sujet d'une situation d'isolation complète imposée expérimentalement à celui d'association intime avec les autres singes rend plus claire la nature des mécanismes de comportement à la base

FOLEY

DAS ZWEITE JAHR DER ENTWICKLUNG EINES RHESUSAFFEN (*MACACA MULATTA*), DER WAHREND DER ERSTEN ACHTZEHN MONATE IN ISOLIERUNG AUFWUCHS

(Referat)

Diese Abhandlung ist eine Forsetzung einer fruher berichteten Untersuchung und beschreibt das zweite Jahr der Entwicklung eines Rhesusaffen (*Macaca mulatta*), der in vollkommener Trennung von der Mutter und anderen Mitgliedern der Gattung wahrend der ersten 18 Monate aufwuchs, und der mit anderen Affen im Laboratorium untergebracht wurde.

Der Autor betont die Notwendigkeit einer ausfuhrlichen Kenntnis der besonderen psychogenetischen Geschichte oder Reaktionsbiographie irgend eines Tieres, das zu experimentellen Zwecken gebraucht wird Der Rest der Abhandlung beschaftigt sich mit dem eigentlichen Experiment, das eine Beschreibung des Problems, Fundortes, Dietat, und eine Eroiterung der Ergebnisse enhalt Diesbezugliche Ergebnisse von anderen Experimenten werden womoglich angegeben Die Ergebnisse werden unter drei Hauptuberschiften besprochen, mit besonderer Berucksichtigung der dritten

1 Physische Entwicklung
2 Sinnesmotor- und einfache Verhaltungsentwicklung
3 Komplizierte Verhaltungsentwicklung

Die letzte Kategorie schliesst eine Besprechung des Fressverhaltens, der Vokalisation, koordinierten Ergreifens und der Handhabung, Spieltatikkeiten, affektiven Verhaltens, Damensaugens, Manieriertheiten, anormalen Reaktionen, und Gewohnheitsruckstande, Geschlechtsverhaltungsweisen, Reaktionen auf andere Tiere, sozialen Gruppierungen, hervorragenden Personlichkeitszuge, Wahrnehmungs- und Vorstellungsverhaltens, und Pflegens ein

Nicht nur wird die allmahliche Entwicklung von solchem Verhalten beschrieben, sondern auch wird der Versuch gemacht, die Erwerbung der verschiedenen Reaktionssysteme mit den besonderen Reizungsumstanden zu korrelieren, die sie erzeugt haben Die plotzliche Anderung des Versuchtieres von einer auferlegten Situation der vollkommenen Trennung zu einer der intimen Assoziation mit anderen Affen erleuchtet die Natur des unterliegenden Verhaltungsmechanismus.

FOLEY

THE AGE FACTOR IN REMINISCENCE: A COMPARATIVE STUDY OF PRESCHOOL CHILDREN AND COLLEGE STUDENTS*

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GRACE O. MCGEOCH

PROBLEM

In a recent critical review (4) of the experimental literature on reminiscence, a phenomenon there defined as "the improvement in the recall of incompletely learned material after an interval of time without intervenient formal relearning or review," it was concluded that the relationship between age and reminiscence had not yet been established. Attention was called to the fact that the results of those experiments in which apparent age differences were obtained (1, 2) did not justify the conclusion that age is a factor in reminiscence since there was a lack of uniformity in experimental conditions with the different age levels, particularly in the materials learned. Moreover, Williams' experiment (6), in which the learning material was constant, did not throw light upon the relationship between age and reminiscence because his published results are in terms of the percentage of retention of the group, a criterion of reminiscence demonstrated to be inadequate.

More recently Liang[1] found no significant age differences in reminiscence in terms of the same criterion, and concluded that "the factor of age differences so much emphasized in Ballard's and Williams' findings could not be reproduced under more carefully controlled conditions so far as the aggregate percentage of retention was concerned." Liang used two age groups, 648 children whose average age was 11.2 years, and 353 college freshmen whose average age was 19.5 years, equated degrees of learning of Chinese ballad poetry, and five intervals, one, two, three, four and five days. For the one- and two-day intervals, however, the percentages of children showing

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[1]The study by Luh and Liang (3) was brought to the writer's attention through the courtesy of the senior author after the completion of the present experiment.

the young animals were, in effect, blind The older rats used in this experiment could obviously see the door at greater distances, and so could orient to it [8]

So far the discussion has not considered the factor of practice. When Phi values (averages for four animals and successive groups of 10 trials) at each age level are plotted as a function of practice the curves shown in Figure 6 result.[9] Neglecting again the 14-day group, one discovers that in the case of the younger animals Phi is

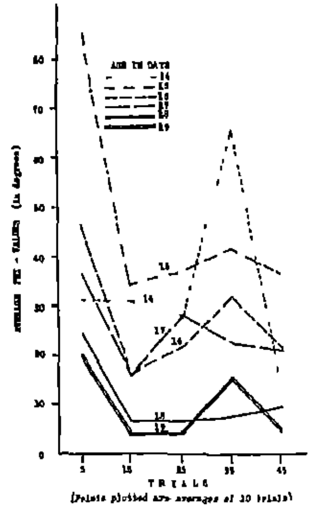

FIGURE 6

LEARNING CURVES SHOWING AVERAGE PHI VALUES OF SUCCESSIVE GROUPS OF 10 TRIALS EACH, FOR EACH AGE LEVEL

(These curves are based only upon orientations made within four inches of the exit door)

[8]Crozier and Pincus reported "seeking of the dark" even in hooded rats under 14 days of age (after the eyes had been artificially opened) The experimenter has enucleated both eyes of a 14-day-old hooded rat, and found no discernible cloudiness of the media Such eyes formed clearly recognizable images of a lighted window at a distance of 10 feet This marked difference between the eyes of the young albino rat and those of the young hooded rat, if typical, quite readily account for the differences between the behavior of Crozier and Pincus's animals and that of the animals used in the present study

[9]The curves shown in Figure 6 are based only on behavior occurring within four inches of the door, since in this region one can be certain that most of the animals were not "blind" The rises in the curves follow the rest periods

originally quite high, falls sharply, but does not reach the low level attained by the older animals. The older animals, moreover, start with Phi values far lower than those which chance orientations would yield, and reach in the case of the 19-day-old animals a level of 5°. This last value is well within the range of tolerance provided by the angular magnitude of the door at the distances under consideration In general, these curves imply that the older animals needed little practice for superior orientations, that whatever they needed to learn was learned during the first few trials.

Just what the animals had to learn is a most important problem. If only the behavior of the 19-day-old animals is considered, one can be *fairly certain that* failures to orient do not result from cloudy ocular media; rather can such failures be ascribed to one or both of *two* factors: (1) lack of training regarding the exit-significance of the visual cue afforded by the exit door and half-cylinder, and (2) an inability to orient to the door, once its exit significance had been learned. In making a test of any theory which asserts the necessity of specific and lengthy practice for accurate orientation, one must decide upon the relative importance of the first factor during the behavioral changes observed. Consideration of certain details of the behavior of the 19-day-old animals during the first few trials permits one to draw rather definite conclusions regarding this point.

In Tables 1 to 4 are included data taken from the record sheets described above, data which show the sequences of paths formed by the oldest animals in their first attempts to escape from the orientation box. In each first column the number of the trial is given The second column contains the distances (in inches—and sixteenths of an inch) from the center of the exit door, at which a given path began (Cf. the abscissae of Figure 5) The third column gives the Phi value for each path (Cf. the ordinates of Figure 5). And finally, the fourth column shows the distances in inches of the points of first contact with the wall of the orientation box from the center of the exit door (Cf. the abscissae of Figure 2) Thus, in Table 1 one may observe that during the first trial Rat *E*3-19 departed from the starting-box alley along a path which began at a distance of 12-0 inches from the center of the exit door, this path having a Phi value of 13°; the first contact with the wall of the orientation box occurred at a (circumferential) distance of two inches from the center of the exit door In the second trial the same animal first assumed (at a

TABLE 1
BEHAVIOR SEQUENCES OF RAT *E*3-19 DURING THE FIRST 13 TRIALS

Trial No	Distance of *origin* of initial (or corrected) path from center of exit door	Phi value of initial (or corrected) path	Distance (around the circumference) of first contact with wall from center of exit door
1	12-0	13	2
2	12-0	105	
	12-0	2	0
3	12-0	45	14
4	9-12	8	
	5-14	12	0
5	12-0	30	30
	9-0	46	
	6-8	0	0
6	12-0	23	
	5-8	1	0
7	12-0	3	0
8	12-0	101	26
9	12-0	90	
	12-0	3	0
10	12-0	20	6
11	12-0	4	
	6-0	2	0
12	12-0	2	
	8-14	3	0
13	12-0	1	
	6-12	5	0

distance of 12 inches from the door) a path having a Phi value of 105°, but at the same distance formed a new path (Phi=2°) such that its first contact was at the exit door. In Trial 4 the same animal assumed (at a distance of 9¾ inches from the door) a path having a Phi value of 8°, and moved along this path to a point 5 and 14/16 inches from the door, where it formed a new path having a Phi value of 12° which in turn permitted it to make the first contact with the exit door [10]

[10]A simple geometrical diagram will demonstrate to the reader that unless the animal originally pursued a path whose Phi value equalled

TABLE 2
BEHAVIOR SEQUENCES OF RAT *F6-19* DURING THE FIRST 12 TRIALS

Trial No	Distance of *origin* of initial (or corrected) path from center of exit door	Phi value of initial (or corrected) path	Distance (around the circumference) of first contact with wall from center of exit door
1	12 0	160	34
2	15-0	100	24
3	12-0	9	0
4	9-12	3	0
5	8-4	22	1
6	12-0	40	
	9-0	3	0
7	11-4	109	24
8	12-0	30	
	8-4	2	0
9	13-0	67	
	9-2	4	0
10	12-0	5	
	6-14	3	0
11	9-14	2	0
12	12-0	103	18

Consideration of the other trials shown in Table 1 indicates that, in nine out of the first 13 trials, Rat *E3-19* touched the exit door before it made contact with any other part of the wall of the orientation box (Cf the zeros in the fourth column). Recalling the controls present in the experimental procedure, one can only conclude that these early responses represent orientations mediated by eidoscopic vision. The moderately successful orientation appearing in

zero (that is, unless the animal started out directly for the center of the exit door), and if it adhered to a given path, the long axis of its body would have formed progressively larger angles with the shortest route to the door from any given point on the path. Hence, in order to reach the exit door any animal generally had to reorient as it came closer to the wall It will be noted in Tables 1-4 that within certain given trials Phi's do not necessarily decrease with reorientation at shorter distances from the door, that state of affairs is made possible by the fact implied by Footnote 6 (the present study), namely, that at shorter distances the animals could deviate more from the *center* of the door and yet make the first contact with some part of the door.

TABLE 3
BEHAVIOR SEQUENCES OF RAT *E*2-19 DURING THE FIRST 12 TRIALS

Trial No	Distance of *origin* of initial (or corrected) path from center of exit door	Phi value of initial (or corrected) path	Distance (*around the circumference*) of first contact with wall from center of exit door
1	12-0	100	36
2	12-0	22	
	10-8	141	28
3	12-0	29	
	8-14	23	4
4	11-2	22	
	9-2	25	2
5	12-0	64	14
6	12-0	100	32
7	10-6	21	4
8	12-0	60	16
9	12-0	62	
	10-14	36	
	6-12	98	8
10	12-0	135	32
11	12-0	60	16
12	12-0	19	
	5-2	3	0

the first trial may have been accidental, but one can hardly regard the other perfect ones as being due to a chance combination of factors Glancing rapidly down the third column of Table 1, one may detect what appears to be a progressive reduction of Phi with practice However, considering the distances (in the second column) one notes that, even in the first trials, paths assumed at short distances resulted consistently in successful orientations The most marked reduction in Phi occurred at the greater distances. Consideration of this last fact, and of the additional one that at distances of 12-0 inches the animal was almost always in contact with the starting box, leads to the conclusion that during practice the effectiveness of the starting box as a thigmotactic stimulus progressively decreased But even in the earliest trials, once contact with the starting box was broken, visual orientations of a high degree of accuracy were possible.

TABLE 4

BEHAVIOR SEQUENCES OF RAT *E*1-19 DURING THE FIRST 10 TRIALS

Trial No.	Distance of *origin* of initial (or corrected) path from center of exit door	Phi value of initial (or corrected) path	Distance (around the circumference) of first contact with wall from center of exit door
1	9-8	105	
	9-8	33	
	9-8	36	6
2	12-0	54	
	8-8	17	2
3	13-0	135	42
4	12-0	71	
	11-0	90	
	12-0	180	40
5	12-0	63	12
6	12-0	30	
	7-10	32	2
6a	12-0	6	
	8-4	18	
	4-12	7	0
7	12-0	170	
	16-0	8	
	6-6	2	0
8	12-0	72	18
9	12-0	13	
	6-6	0	0
10	12-0	40	10

The contents of Table 2 (Rat *F*6-19) lead to similar conclusions In addition it is interesting to note that the animal either contacted the wall at the door, or at a distance of at least 18 inches from the door; the sole exception to this rule appears in Trial 5. The behavior of several of the younger animals had this same "all-or-none" character, such animals either approached the door or—to all appearances—reacted on the basis of some other cues Trials 1 and 2 in Table 2 indicate the type of behavior manifested by an animal untrained in regard to the exit-significance of the door

If the contents of Tables 1 and 2 can be taken as indications that eidoscopic orientation as defined by Phi does not have to be learned,

those of Table 3 (Rat $E2$-19) indicate that some animals must *learn to reorient after running some distance along an assumed path.* This animal began to show perfect orientations by the end of the seventeenth trial, so that 50% of the trials that followed yielded first contacts at the exit door.

Table 4 (Rat $E1$-19) shows again the decrease in Phi at distances at which the animal is in contact with the starting box. Low Phi's at short distances are present in the first five trials, and appear more often in the later trials as the decreasing effectiveness of the thigmotactic stimulation from the starting box enabled the animal to reorient during more accurate initial orientations.

To summarize: Successful and fairly accurate orientations at short distances appear during the first five trials of three of the animals at a frequency for which one could not account by assuming a fortunate combination of chance factors. The prevalence of such behavior constitutes evidence that the animals began their attempts to reach the door with a highly developed behavioral mechanism for running *towards* the door, and that they did not have to pass through an extended period of trial-and-error behavior in order to reduce Phi by any appreciable amount. Practice probably did reduce the effectiveness of the thigmotactic stimulation which generally occurred during the assumption of the initial path. The behavior of one of the animals suggests also the possibility that practice led to more timely corrections of an error created by continued locomotion along a given path. Two of the animals learned quite rapidly the exit-significance of the visual cue.

If in some way eidoscopic orientation as measured by Phi did have to be learned, that learning process was either too rapid or implicit to be detected by the method of analysis described in the present article. However, the analysis of the behavior of the 19-day-old animals during their first 10 to 13 trials in the orientation box indicates clearly that these animals were capable of quite accurate eidoscopic orientations, without having had beforehand practice specific to the total behavior in question.

One age difference disclosed by the present study lies in the more rapid locomotion manifested by the older animals used. Average maximum velocities attained during successful trials were 8.9, 10.2, 9.8, 11.3, 13.2, and 13.0 inches per second at ages 14, 15, 16, 17, 18, and 19 days respectively. Thus, at 19 days velocities were attained

which were almost one-half again as large as those attained at 14 days

It was thought in addition that older animals would be able to maintain higher running speeds while changing the direction of their locomotion on the basis of the localized visual cue. The minimum velocities (average) appearing in successful trials at regions in which new paths were assumed were 4.0, 4.7, 5 0, 8.0, 9 2, and 8 3 inches per second for the respective ages from 14 to 19 days.[11]

Subtracting the minimum velocities from the maximum velocities given above yields the following decelerations for reorientation at the age levels from 14 to 19 days: 4.9, 5.5, 4 8, 5 3, 4.0, and 4.7 inches per second Thus there tends to be if anything only a slight drop with increasing age. When these decelerations are expressed as percentages of the corresponding maximum velocities attained there is, as one would expect, a decrease with increase in age. For ages 14 to 19 days respectively the percentages are: 55.0, 53 9, 49.0, 46.9, 30.3, and 36 2.

One may conclude that older animals attain greater maximum velocities while running; and that they maintain greater velocities and need to decelerate less in proportion to maximum velocities attained, while reorienting to a localized visual stimulus.

Summary

1 Apparatus for the investigation of non-tropistic visual orientation ("eidoscopic orientation") in the young albino rat is described. Illumination is used simultaneously for vision, photographic recording, and motivation.

2. A measure (Phi) of the eidoscopic orientation of the total organism is defined and applied to the orientations of 22 albino rats between the ages of 14 and 19 days

3. Without previous practice in such behavior 19-day old albino rats orient within an average error of 20°, after a few trials the average performance drops to 5°. Detailed consideration of the

[11]It is interesting that the most marked rise in minimum velocity occurs between 16 and 17 days (5 0 to 8 0 inches per second), or during the interval in which the last cloudiness of the lens disappears. One might conclude that clear vision outside the region of fixation is related in some way to the speed of response during eidoscopic reorientation, however, a marked increase in locomotor ability might also contribute to such a change

initial trials of these animals leads to the conclusion that the learning concerns primarily the acquisition of exit-significance by the critical stimulus, and not the gradual reduction of the error of orientation by a laborious trial-and-error process.

4 Younger animals are capable of visual orientations the accuracy of which is greatly reduced by remarkable inferior distance vision, and by the consequent difficulty with which the exit-significance of the critical cue is learned

5 The inferior distance vision of the younger animals is most probably related to a cloudiness of the optic media, which tends to disappear completely by the time the albino rat is 16 or 17 days old.

6. Older animals can attain greater maximum velocities than can the younger ones, and can maintain greater velocities while reorienting with respect to a localized visual stimulus.

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LE DÉVELOPPEMENT DE LA PERCEPTION. I LA DIRECTION VISUELLE; LES PREMIÈRES ORIENTATIONS EIDOSCOPIQUES DES RATS BLANCS

(Résumé)

Les orientations dans l'espace de jeunes rats blancs ayant les yeux capables de former les images (yeux eidoscopiques) diffèrent des orientations tropiques des rats ayant les yeux non encore ouverts (yeux euthoscopiques) Des images cinématographiques du comportement de 22 rats blancs ayant de 14 à 19 jours demontrent que de tels animaux sans expérience précédente peuvent faire usage de la vision eidoscopique pour s'orienter en rapport avec un stimulus circonscrit Une measure (Phi) de la précision de ces rapprochements montre, pendant les premiers 10 essais d'animaux ayant 19 jours, une erreur moyenne de 20° Après 10 autres essais cette erreur est reduite à 5° Cependant, une inspection des résultats individuels montre que par la pratique les animaux apprenent actuellement la signification du stimulus crucial, et de plus que la pratique spécifique n'est pas nécessaire

pour l'orientation précise Les milieux dioptriques des rats blancs qui ont moins de 17 jours sont nébuleux, *de sorte que leur vision et leur orientation* eidoscopique sont très affectées par la distance Les rats plus vieux non seulement peuvent s'orienter à une distance plus grande, mais aussi peuvent arriver à une locomotion plus rapide, et peuvent maintenir une vitesse plus grande pendant les reorientations eidoscopiques

TURNER

DIE ENTWICKLUNG DES AUFFASSENS· I. DIE SEHRICHTUNG; DIE FRÜHESTEN EIDOSKOPISCHEN ORIENTIERUNGEN BEI DER WEISSEN RATTE

(Referat)

Die raumlichen Orientierungen bei den jungen weissen Ratten, die die bildformenden (d h., eidoskopischen) Augen haben, weichen von den Phototropismen der Ratten ab, die noch geschlossene (d.h., euthoskopische) Augen haben. *Ergebnisse, die aus der kinematographischen Beobachtung von* zweiundzwanzig 15 bis 19 Tage alten weissen Ratten gewonnen wurden, zeigen, dass solche Tiere ohne vorhergehende Dressur fähig sind, das eidoskopische Sehen fur die Lokalisierung und Annaherung eines eingeschrankten Reizes zu verwenden. Eine Messung (Phi), die die Genauigkeit solcher Annaherungen darstellen soll, weisst wahrend der ersten 10 Versuche einen mittleren Fehler von 20° auf Nach 20 Versuchen wird dieser Fehler gleich 5° Indessen zeigt eine Untersuchung der einzelnen Versuchsergebnisse, dass eine Erfahrung der Bedeutung des Hauptreizes der hauptsächliche Inhalt der Dressur ist, und ferner, dass die spezifische Dressur fur die genaue Orientierung nicht notig ist *Die Augenmedien der* weissen Ratten, die weniger als 17 Tage alt sind, sind wolkig, so dass das Fernsehen und die eidoskopische Orientierung unter dieser Beschrankung leiden Die alteren Ratten sind nicht nur in der Lage, sich in grosseren Entfernungen besser zu orientieren, sondern auch grossere Geschwindigkeiten wahrend der Ortsveranderungen zu erreichen, *sowie auch wahrend* der eidoskopischen Wiederorientierungen grossere Geschwindigkeiten zu erhalten.

TURNER

POSSIBLE GENETIC RELATIONSHIPS AMONG QUINTUPLETS*

NORMA V SCHEIDEMANN

The recent arrival in Canada of five infants at a single birth is attracting a popular, world-wide interest, for it is estimated that quintuplets are born only once in 57,000,000 deliveries This multiple birth is phenomenal—according to medical records it has not occurred anywhere in the civilized world during the last forty-five years and only thirty-three times since 1694—but even more re-

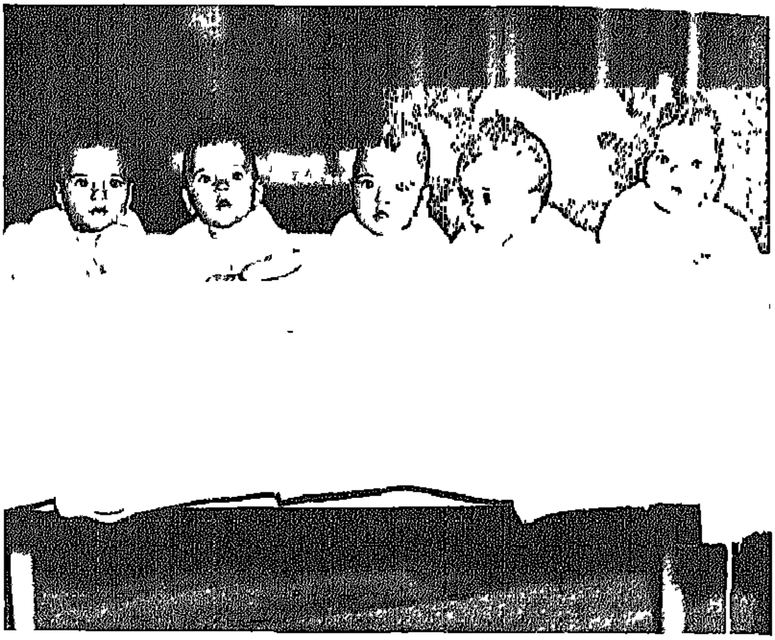

FIGURE 1
THE DIONNI QUINTUPLETS AT EIGHT MONTHS OF AGE
(Courtesy of N E A Service, Inc)

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markable is the fact that all the infants have survived an appreciable period of time. No previous set has survived more than fifty minutes.

Should these children continue to live it will be but a matter of time before many speculations will be advanced in regard to their possible genetic relationships Similarities and dissimilarities, both normal and pathological, will be investigated as bases for assumptions. Many conclusions will be presented that will be of questionable value since even our best methods of gathering pertinent data are crude In general, the simplicity of the conclusions will be in inverse proportion to the fineness of the units of measures utilized Moreover, many investigators will lose sight of the fact that our present knowledge of the genesis and relationship of multiple offspring is primarily theoretical, is very limited, and is characterized by convenient simplicity

The literature on the subject of multiple births is devoted largely to the process of twinning, since in other forms the twinning process is repeated either simultaneously or in rapid succession It is recognized that the findings in the case of twins are applicable to other forms of multiple births, but there is a tendency to interpret all forms in terms of the simple twin theories. How complicated the genetic relationship of quintuplets may be, may not be realized until we are confronted with a graphic presentation of the various modes of genesis and of fertilization resulting in quintuple offspring, and then deducting the various types of relationship from the graphs.

In the case of twins, two general types commonly are recognized, single ovum (monozygotic) and biova (dizygotic). Monozygotic twins often are referred to as duplicate or identical, since they are found to be very much alike; their genesis is thought to be a single ovum fertilized by a single spermatozoon Dizygotic twins, called sibling or fraternal, are not found to bear as close resemblance as the monozygotic The resemblance usually is closer than that of siblings of different ages since contemporaneous spermatozoa and ova perhaps are more alike than those developed at different times Dizygotic twins are thought to originate from two ova fertilized by two spermatozoa

Koch (11, 12) made a study of a pair of Siamese twins who, because of the nature of their conjunction, evidently represented an incomplete organic separation rather than a fusion of disparate

individuals Such twins commonly are considered identical and doubtless they are of uniovular origin However, in the particular pair studied it was disclosed that, despite many marked similarities, differences in physical and mental traits were quite apparent. These findings suggest that uniovular twins are not always wholly identical.

In measuring fifty pairs of unselected public school twins, Thorndike (22, p 44) found their resemblance to be approximately .80 in amount Ranking all these twin pairs according to their degree of resemblance resulted in a curve (Figure 2) that led the in-

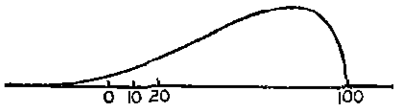

FIGURE 2
DISTRIBUTION OF RESEMBLANCE CURVE OF 50 PAIRS OF TWINS
(From Thornkike, 22)

vestigator to question whether twins represented two distinct modes of fertilization and genesis. Instead of a bimodal curve, the curve showed a gradual grading from the closest likenesses to notable differences Moreover, the twins most identical in *some* respect were found to be less like each other than ordinary siblings

In regard to the extent of similarity in biovular twins Danforth says:

> It may be assumed that biovular twins will on the whole resemble each other to a degree about equal to the average for all children of the same family In individual sets the degree of resemblance will vary widely, since the possible combinations of traits from the maternal and paternal germ plasms are very many.[1] It is conceivable that occasionally (with our population and birth rate, perhaps once in eight or ten years) a pair of biovular twins would be born with identical germ plasms More frequent should be biovular twins differing in only one chromosome, and progressively more frequent the pairs differing by larger and larger degrees until the average of fraternal resemblance is reached Then progressively less frequent should be pairs differing to increasing degree below the fraternal average (6)

[1]On the assumption that chromosomes maintain their individuality and that "crossing over" does not occur, there would still be no less than 4,096 possible kinds of germ cells to be produced by a given individual of either sex [Danforth's footnote]

Biologists have presented various modes of monozygotic twinnings. Thus Newman (15, p 131) says that there are three, namely:

1. Fission of the blastoderm,
2. Double gastrulation, and possibly
3. Complete fission of the bilateral halves of a single embryonic axis.

Williams (8, p. 425) recognizes four possible ways in which single-ovum twins may be produced:

1. Fertilization of two polar bodies,
2. Premature separation of one or more blastomeres from a segmenting ovum,
3. Cleavage of the embryonic area, and
4. Double gastrulation of the blastodermic vesicle.

A retarding agency in the development of the fertilized egg commonly is considered conducive to the twinning phenomenon. Three possible retarding agents are cited by Newman (15, pp. 133-134) as follows:

1 *Understimulation of the egg due to some defect in the development-initiating mechanism of the sperm.* Davenport's findings indicated that twinning is inherited rather strongly in the male line. Newman indicated that only one-egg twinning could be inherited through the male line, for twinning as a result of this factor could be possible only in the case of monozygotic twins, since dizygotic twinning is a phenomenon of ovulation and does not involve the male. An understimulated ovum would be retarded and consequently would undergo belated fission; the degree of retardation would determine significant consequences.

2 *Belated placentation due to failure of the corpus luteum to stimulate the uterine mucosa.* According to Newman some "physiological discoördination between the various intricately interdependent factors responsible for implantation of the ovum" are involved in this situation. The objection that a given mother always would produce twins, since presumably the same mechanism would persist throughout reproductive life, is met by the suggestion that perhaps single offspring from parents exhibiting one-egg twinning are not true single offspring, but represent survivors of pairs of twins, others of which succumbed to hazards pertinent to one-egg twinning. Newman considers this the least objectionable theory of twinning in man.

3. *An hereditary character dependent upon a recessive gene.* A temporary "period of quiescence," caused by a gene acting as a growth-retarding factor, may result in a belated placentation and in turn in twinning. Twinning, according to this theory, could be transmitted as readily through the female line as through the male Some of the zygotes, in the case of parents heterozygous for the twinning gene, would be monozygous for the character and twinning would result. Single offspring could occur also in such matings. This gentic theory of twinning is regarded as being rather fantastic by Newman, but in view of Davenport's findings Newman does not wish to exclude it as one of the possibilities.

In general, all theories of twin genesis may be grouped into four categories, namely, those pertaining to

1. Ovulation and sperm maturation,
2. Fertilization,
3. Ovum fission, and
4. Chromosomal characters.

The causes and modes of ovum fission are covered by Newman's and Williams' theories presented above Davenport's findings have been cited to support ovum segmentation as a result of chromosomal characteristics In these theories fertilization is taken to be the result of a single spermatozoon uniting with a single ovum (except Williams' theory of fertilization of two polar bodies which necessarily would require two spermatozoa).

A chromosomal theory, other than a growth-retarding gene, may account for additional modes of multiple genesis. During the series of cell divisions, the chromosomes of sex cells divide longitudinally by the typical process of mitosis and retain their number throughout In the case of quintuplets possibly this mitotic division is a quintuple division (due to a recessive gene, stimulating mitotic division), not in one of 57,000,000 fertilizations (incidence of quintuplets), but in one of 17,442,000,000 cases (if all types of quintuple genesis cited below occur about equally) Quintuple longitudinal division would result in five sets of chromosomes so that a five-nuclear formation would be possible in both the male and in the female cells Gesell indicates this possibility of multiple mitotic division.

> We must recognize the indisputable occurrence occasionally of an ovum with double germinal visicle (two nuclei) Boveri

> has suggested the additional possibility—actually demonstrated on eggs of sea-urchins and bees—that a sperm may occasionally unite with only one half of a precociously divided ovum, leaving the other half to develop parthenogenetically (Danforth). (8, p 425)

It is possible for an ovum to be penetrated by *two* spermatozoa This does not happen customarily. That it does happen infrequently, however, is indicated by Holmes.

> Eggs frequently exhibit a curious reaction which prevents them from being entered by more than one sperm The first sperm cell that succeeds in penetrating into the egg cytoplasm stimulates it to undergo a change at the surface, which prevents other sperms from gaining entrance. Were it not for this delicate and rapid reaction, eggs might be fertilized by several sperm cells When this occurs, as it does under exceptional circumstances, it frequently leads to abnormalities of development (9, pp 156-157)

When the "exceptional circumstances" include a five-nuclear ovum, the simultaneous penetration of five spermatozoa may cause no abnormality of development other than five well-formed offspring—uniovum-quintuple-spermatozoa quintuplets. Should but one spermatozoon penetrate a multiple-nuclear ovum, only one nucleus could be developed.

Furthermore, it must be recognized that possible quintuplet relationships *may be multiplied according to the relationship of the* fertilizing male cells In the female sex-cell, cell division is very unequal so that only one large cell matures and three small polar bodies, formed by reduction division, soon disintegrate without taking part in development The cell division in the case of the male cell is equal and takes place twice so that *four* spermatozoa result from the maturation of a single male germ-cell (Figure 3). Since these four germ-cells are derived from the same single cell, they may be considered "identical." According to current views the four germ-cells are comprised of two sets of two identical cells, that is, only cells and their polar bodies are considered identical. However, the four mature cells that are derived from a single cell are of identical structure and may well be considered identical These four cells, moreover, may be in closer juxtaposition and may have equal characteristics of virility and attractability to the same or to several germ-cells of the opposite sex Thus, multiple off-

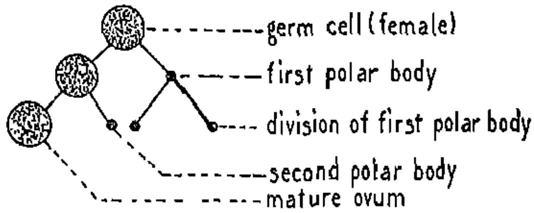

FIGURE 3

DIAGRAM SHOWING THE GENESIS OF THE OVUM
(After T Voveri)

A similar diagram in which all the daughter cells are of equal size would illustrate the genesis of four spermatozoa

spring may be paternally identical or paternally sibling according to whether they are fertilized by identical or by sibling spermatozoa respectively. Likewise, offspring may be maternally identical or maternally sibling according to whether they are developed from identical or from sibling ova respectively

In order to analyze all possible relationships among quintuplets it may be expedient to list all possible types of spermatozoa and ova that may be the genesis of quintuple offspring. Table 1 presents these respective types

The various possible modes of fertilization of each of these germ-cells are graphed in Figure 4. The particular occurrences of mitosis are not designated in this schema; they are so obvious that the reader will readily understand where they take place. This figure indicates that there are 206 possible modes of fertilization of germ-cells giving rise to quintuplets These modes do not discriminate between types of monozygotic twinning enumerated above, nor do they include the theory of polar-body fertilization presented by Williams, nor do they include possible alternate successive divisions in several cases

It may seem reasonable to infer that a later fission of the fertilized ovum may result in a greater similarity among multiple offspring than an earlier fission. Since this can not be presented expediently in schema only pre- and post-fertilization divisions are considered The fertilization of a polar body is not considered since

TABLE 1

TYPES OF GERM-CELLS THAT MAY BE POSSIBLE GENESIS OF QUINTUPLET OFFSPRING

Male	Female
1 sperm	1 ovum
2 sib. sperms	2 sib ova
2 iden sperms	2 iden ova
3 sib. sperms	3 sib ova
3 iden sperms	3 iden ova
4 sib. sperms	4 sib. ova
4 iden sperms	4 iden ova
5 sib. sperms	5 sib. ova
5 iden sperms	5 iden ova
1 sib, 2 iden. sperms	1 sib, 2 iden ova
1 sib, 3 iden. sperms	1 sib, 3 iden ova
1 sib, 4 iden sperms	1 sib, 4 iden. ova
2 sib., 2 iden sperms	2 sib, 2 iden ova
2 sib, 3 iden sperms	2 sib., 3 iden. ova
3 sib, 2 iden. sperms	3 sib., 2 iden. ova
1 5-nuc sperm	1 5-nuc. ovum
1 4-nuc. sperm	1 4-nuc ovum
1 3-nuc. sperm	1 3-nuc. ovum
1 2-nuc. sperm	1 2-nuc ovum
1 4-nuc, 1 sib. sperms	1 4-nuc, 1 sib. ova
1 4-nuc, 1 iden sperms	1 4-nuc., 1 iden ova
1 3-nuc., 1 sib sperms	1 3-nuc, 1 sib ova
1 3-nuc., 1 iden sperms	1 3-nuc., 1 iden. ova
1 3-nuc., 2 sib. sperms	1 3-nuc, 2 sib ova
1 3-nuc., 2 iden. sperms	1 3-nuc, 2 iden. ova
1 3-nuc., 1 2-nuc sperms	1 3-nuc., 1 2-nuc ova
1 3-nuc., 1 iden, 1 sib. sperms	1 3-nuc, 1 iden., 1 sib. ova
2 2-nuc sperms	2 2-nuc. ova
2 2-nuc., 1 sib. sperms	2 2-nuc, 1 sib ova
2 2-nuc, 1 iden sperms	2 2-nuc, 1 iden. ova
1 2-nuc., 1 sib sperms	1 2-nuc, 1 sib ova
1 2-nuc, 1 iden. sperms	1 2-nuc, 1 iden. ova
1 2-nuc., 1 iden., 1 sib. sperms	1 2-nuc., 1 iden, 1 sib ova

a pre-fertilization division of ovum offers all the possibilities of a mother cell and a polar body. Moreover, a divided unfertilized ovum might be more susceptible to fertilization and development than a polar body, since sufficient cytoplasm may be provided for each division in contrast to the limited amount of cytoplasm supplied a polar body. However, if the reader wishes to include the possibilities of fertilized polar bodies he may bear in mind that the

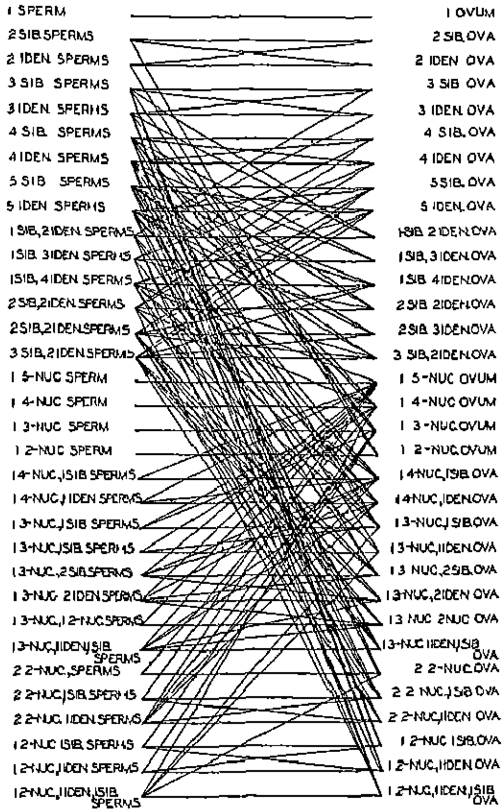

FIGURE 4

POSSIBLE MODES OF FERTILIZATION

possibilities of fertilization and the relationships among quintuplets from this source are the same as those of the identical ova (unfertilized divided ovum) (Ordinarily the ovum and the first polar body are not thought of as other than sibling, but since they are of the same structure they may be considered as identical)

Table 2 outlines the relationships among quintuplets according to the germ-cell genesis and fertilization shown in Figure 4

TABLE 2

POSSIBLE QUINTUPLET RELATIONSHIPS ACCORDING TO GERM-CELL GENESIS AND FERTILIZATION

Genesis	Relationship
I. 1 ovum	
x 1 S, then 5	5 iden.
(Divisions may be either simultaneous or successive)	
II 2 sib ova	
x 2 sib S, 1 4	4 iden.; 1 sib.
x 2 sib. S, 1 3, 1:2	1 set 3 iden , 1 set 2 iden.
x 2 iden S, 1 4	4 iden , 1 pat. iden , mat sib
x 2 iden S, 1 3, 1 2	1 set 3 iden , 1 set 2 iden Each set pat. iden , mat sib. to other set
III. 2 iden. ova	
x 2 iden S, 1:4	5 iden
x 2 iden. S, 1:3, 1:2	5 iden
x 2 sib. S, 1 4	4 iden., 1 pat. sib , mat iden.
x 2 sib S, 1:3, 1 2	1 set 3 iden , 1 set 2 iden Each set pat sib mat iden to other set
IV. 3 sib ova	
x 3 sib. S, 1 3	3 iden., 2 sib
x 3 sib S, 2 2	2 sets of 2 iden , 1 sib
x 3 iden S, 1 3	3 iden ; 2 pat iden, mat sib
x 3 iden S, 2:2	2 sets of 2 iden.; 1 pat iden., mat sib. Each set pat iden., mat sib. to remaining 3
x 1 sib. and 2 iden. S, 1.3	3 iden ; 2 pat iden, mat. sib
x 1 sib. and 2 iden S, 1:3	3 iden , 1 sib , 1 mat sib , pat iden to the iden , pat sib to the sib
x 1 sib and 2 iden S, 2:2	2 sets of 2 iden , 1 mat sib , pat iden to one set of iden , and pat. sib. to other set
x 1 sib. and 2 iden S, 2 2	
V. 2 iden. ova	
x 3 sib S, 1.3	3 iden., 2 pat sib., mat iden
x 3 sib. S, 2 2	1 pat. sib , mat , iden.; 2 set of 2 iden , each set pat sib , mat iden to remaining 3.
x 3 iden S, 1 3	5 iden.
x 3 iden S, 2 2	5 iden
VI 4 sib ova	
x 4 sib. S, 1.2	2 iden , 3 sib
x 4 iden S, 1 2	2 iden.; 3 pat iden , mat sib.
x 1 sib and 3 iden S, 1 2	2 iden ; 3 pat. iden. to each other and pat. sib to the iden , mat sib
x 1 sib and 3 iden S, 1 2	2 iden , 1 sib , 2 mat sib., pat iden to iden and pat sib to sib
x 2 sib and 2 iden S, 1 2	1 sib , 2 iden., 2 pat iden to each other, mat sib to all others
x 2 sib and 2 iden. S, 1:2	2 sib , 2 iden.; 1 mat sib., pat iden to one set of iden , pat sib to other set

TABLE 2 (*Continued*)

Genesis	Relationship
VII 4 iden ova	
x 4 sib S, 1 2	2 iden., 3 pat sib, mat iden
x 4 iden S, 1 2	5 iden
x 1 sib and 3 iden S, 1 2	1 set of 2 iden , 1 set of 3 iden Each set pat sib and mat iden to other set
x 1 sib and 3 iden S, 1 2	4 iden ; 1 pat sib, mat iden
x 2 sib and 2 iden S, 1 2	2 sets of 2 iden Each set pat sib and mat iden to remaining 3 1 pat sib, mat iden to all others
x 2 sib and 2 iden. S, 1 2	3 iden , 2 pat sib, mat. iden to all others.
VIII 5 sib. ova	
x 5 sib S	5 sib
x 5 iden S	5 pat iden., mat sib.
x 1 sib and 4 iden S	1 sib , 4 pat iden to each other, mat sib
x 2 sib and 3 iden S	2 sib , 3 mat sib., pat iden to each other, but pat sib. to the sib
x 3 sib and 2 iden S	3 sib , 2 mat sib, pat iden to each other, but pat sib. to the sib
IX 5 iden ova	
x 5 sib S	5 pat sib, mat iden
x 5 iden S	5 iden
x 1 sib and 4 iden S	4 iden , 1 pat sib, mat iden
x 2 sib and 3 iden S	3 iden , 2 pat sib, mat iden
x 3 sib and 2 iden. S	2 iden , 2 pat sib, mat iden
X. 1 sib and 2 iden ova	
x 3 sib. S, 2 2	2 sets of 2 iden , 1 pat sib, mat iden to one set of iden, and mat sib to other
x 3 sib S, 2 2	1 sib , 2 sets of 2 idens, mat iden to each other
x 3 iden S, 2 2	1 set of 3 iden , 1 set of 2 iden Each set pat iden, mat sib to other set
x 3 iden S, 2 2	4 iden , 1 pat iden, mat sib
XI 1 sib and 3 iden ova	
x 4 sib S, 1 2	2 iden , 3 pat sib, mat iden to each other, mat sib. to the iden
x 4 sib S, 1 2	1 sib , 2 iden , 2 pat sib, mat iden to each other and pat sib to other 3
x 4 iden. S, 1 2	1 set 3 iden , 1 set 2 iden Each set pat iden. mat sib to other set
x 4 iden S, 1 2	4 iden ; 1 sib
XII 1 sib and 4 iden. ova	
x 5 sib S	1 sib ; 4 pat sib, mat iden
x 5 iden S	4 iden ; 1 pat iden, mat. sib
x 1 sib and 4 iden S	4 iden ; 1 sib
x 2 sib and 3 iden S	3 iden ; 1 sib , 1 pat sib, mat iden to the iden, mat sib to the sib

TABLE 2 (*Continued*)

Genesis	Relationship
x 3 sib and 2 iden S	2 iden ; 1 sib , 2 pat. sib , mat iden to the iden , mat. sib. to the sib.
XIII 2 sib and 2 iden ova	
x 4 sib. S, 1 2	1 sib.; 2 iden ; 2 mat iden to each other, mat. sib to others, pat sib to all
x 4 sib. S, 1·2	2 sib , 2 iden ; 1 pat sib. to all, mat iden to the iden, mat. sib to remaining 2
x 4 iden. S, 1.2	2 sets of 2 iden., each set pat iden, mat sib to other set 1 pat iden., mat sib
x 4 iden. S, 1 2	3 iden , 2 pat iden., mat sib.
x 1 sib and 3 iden S, 1.2	2 sets of 2 iden , 1 mat sib , pat iden to one set, pat. sib to other set.
x 1 sib and 3 iden S, 1·2	2 sets of 2 iden , each set pat iden to other, 1 sib
x 1 sib and 3 iden S, 1:2	2 iden , 2 pat iden., mat sib , pat iden. to fifth ; 1 mat iden to iden. pat iden to remaining 2.
x 1 sib and 3 iden. S, 1 2	3 iden , 1 sib , 1 pat iden to iden., mat. sib to all
x 2 sib. and 2 iden. S, 1:2	3 iden ; 2 sib
x 2 sib. and 2 iden S, 1.2	1 sib , 2 sets of 2 iden , both sets pat iden
x 2 sib and 2 iden. S, 1 2	2 iden , 1 sib., 1 pat sib , mat iden to fifth , 1 mat iden to iden , pat iden to fifth
x 2 sib and 2 iden S, 1.2	2 iden ; 1 sib , 1 pat iden to iden , mat sib ; 1 mat. iden to iden , pat sib
x 2 sib and 2 iden. S, 1 2	2 iden , 2 mat sib , pat iden ; 1 pat iden to iden , mat sib
x 2 sib and 2 iden. S, 1 2	2 iden ; 2 mat iden , pat sib , 1 mat. sib., pat iden to iden
XIV 2 sib and 3 iden ova	
x 5 sib. S	2 sib , 3 pat sib , mat iden to each other, mat sib to remaining 2
x 5 iden S	3 iden ; 2 pat iden , mat sib
x 1 sib. and 4 iden. S	1 sib ; 3 iden ; 1 mat sib , pat iden to the iden , pat sib to sib
x 1 sib and 4 iden S	2 iden., 2 mat sib , pat iden to the iden , pat sib to remaining 1 , 1 pat sib , mat iden. to the iden , mat sib to remaining 2
x 2 sib. and 3 iden. S	3 iden., 2 sib
x 2 sib and 3 iden S	2 pat sib , mat iden , 2 pat. iden , mat sib ; 1 pat iden. mat sib to one group and pat. sib., mat iden to other.

TABLE 2 (*Continued*)

Genesis	Relationship
x 3 sib and 2 iden S	2 iden, 2 sib; 1 pat sib, mat iden to one set and mat sib to other set
x 3 sib and 2 iden S	3 pat sib, mat iden to each other and mat sib to other two, 2 pat iden, mat sib
x 3 sib and 2 iden S	1 sib, 2 pat sib., mat iden, 1 mat. iden to set of 2, pat iden to remaining 1, 1 mat sib, pat sib to sib., pat iden to remaining 1.
XV 3 sib and 2 iden ova	
x 5 sib. S	3 sib, 2 pat sib, mat iden to each other, mat sib to remaining 3
x 5 iden. S	2 iden; 3 pat iden, mat sib
x 1 sib and 4 iden S	1 sib, 2 iden, 2 pat iden, mat sib.
x 1 sib and 4 iden. S	3 pat iden., mat sib, 1 pat iden to set of 3, mat iden to remaining 1; 1 pat sib, mat sib to set of 3, mat iden to remaining 1
x 2 sib and 3 iden. S	2 iden, 2 sib, 1 pat iden, mat sib to the iden
x 2 sib and 3 iden. S	3 mat sib, pat iden to each other, 2 mat iden to each other, pat sib
x 2 sib and 3 iden. S	1 sib, 2 mat sib, pat iden. to each other, 1 pat iden to set of 2, mat iden to remaining 1, 1 pat sib, mat. sib to sib and set of two, mat iden to remaining 1
x 3 sib and 2 iden S	3 sib, 2 iden
x 3 sib and 2 iden S	1 sib, 2 pat sib., mat iden, 2 pat. iden, mat sib
x 3 sib and 2 iden. S	2 sib; 2 mat iden, pat sib, with 1 pat iden to fifth; 1 mat sib, pat iden to non-sib
XVI 1 5-nuc ovum	
x 5 sib S	5 pat. sib, mat iden
x 5 iden S	5 iden
x 1 sib and 4 iden. S	4 iden, 1 pat sib, mat iden
x 2 sib. and 3 iden. S	2 pat sib, 3 pat iden All mat iden
x 3 sib and 2 iden S	2 iden, 3 pat sib, mat iden
x 1 5-nuc S	5 iden
x 1 4-nuc and 1 sib S	4 iden, 1 pat sib, mat iden
x 1 4-nuc. and 1 iden S	5 iden
x 1 3-nuc and 2 sib S	3 iden, 2 pat sib, mat iden
x 1 3-nuc and 2 iden S	1 set of 3 iden, 1 set of 2 iden Each set mat iden, pat sib to other set
x 1 3-nuc. and 1 2-nuc S	1 set of 3 iden., 1 set of 2 iden Each set mat iden, pat sib to other set
x 1 3-nuc, 1 sib, and 1 iden. S	4 iden., 1 pat sib., mat iden
x 2 2-nuc and 1 sib. S	2 sets of 2 iden., mat iden to each other, 1 mat iden, pat. sib

TABLE 2 (*Continued*)

Genesis	Relationship
x 2 2-nuc and 1 iden S	1 set of 2 iden ; 1 set of 3 iden. Each set mat. iden to other set
XVII. 1 4-nuc ovum	
x 4 sib. S, 1.2	2 iden , 3 pat sib , mat iden
x 4 iden. S, 1 2	5 iden
x 1 sib and 3 iden S, 1.2	1 set of 2 iden , 1 set of 3 iden Each set pat sib , mat iden to other set
x 1 sib and 3 iden S, 1:2	4 iden , 1 sib
x 2 sib. and 2 iden S, 1.2	2 sets of 2 iden , each pat sib , mat iden to other set, 1 pat sib , mat iden to all
x 2 sib and 2 iden S, 1 2	3 iden , 2 pat sib , mat iden to all
x 1 3-nuc. and 1 sib S, 1 2	4 iden , 1 pat sib , mat iden
x 1 3-nuc and 1 sib S, 1 2	3 iden , 2 iden. Each set pat. sib , mat iden
x 2 2-nuc. S, 1 2	1 set 3 iden., 1 set 2 iden All mat iden
x 1 2-nuc , 1 sib , 1 iden. 1 2	4 iden , 1 pat sib , mat iden
XVIII. 1 3-nuc. ovum	
x 3 sib S, 1·3	3 iden ; 2 pat sib , mat iden. to each other and to iden
x 3 sib. S, 2 2	2 sets of 2 iden , each set pat. sib , mat iden to other set, 1 pat sib., mat iden
x 3 iden. S, 1.3	5 iden
x 3 iden, S, 2 2	5 iden
x 1 sib and 2 iden. S, 1·3	3 iden.; 2 iden , pat. sib , mat. iden. to iden.
x 1 sib and 2 iden S, 1 3	4 iden ; 1 pat sib , mat iden.
x 1 sib and 2 iden S, 2:2	2 sets of 2 iden., 1 mat iden , pat iden to one set, sib to other
x 1 sib. and 2 iden. S, 2:2	4 iden.; 1 pat. sib , mat iden
x 1 3-nuc S, 1 3	5 iden
x 1 3-nuc S, 2 2	5 iden.
x 1 2-nuc. and 1 sib S, 1·3	4 iden., 1 pat sib., mat iden
x 1 2-nuc. and 1 sib S, 1 3	1 set of 3 iden , 1 set of 2 iden Each set pat sib, mat iden to other set
x 1 2-nuc and 1 sib S, 2.2	4 iden , 1 pat sib., mat iden
x 1 2-nuc. and 1 sib S, 2:2	1 set of 3 iden ; 1 set of 2 iden Each set pat sib , mat. iden to other set
x 1 2-nuc. and 1 iden. S, 1 2	5 iden
x 1 2-nuc. and 1 iden S, 2·2	5 iden
XIX. 1 2-nuc ovum	
x 2 sib S, 1 4	4 iden ; 1 pat sib , mat iden.
x 2 iden S, 1·3, 1 2	1 set of 3 iden , 1 set of 2 iden Each set pat. sib., mat. iden to other set.
x 1 2-nuc. S, 1·4	5 iden
x 1 2-nuc. S, 1 3, 1 2	5 iden
XX 1 4-nuc and 1 sib ova	
x 5 sib S	1 sib , 4 pat sib., mat iden to each other

TABLE 2 (*Continued*)

Genesis	Relationship
x 5 iden S	4 iden, 1 pat iden., mat sib
x 1 sib and 4 iden S	3 iden, 1 pat. iden, mat sib to the iden., 1 pat sib, mat iden to the iden
x 1 sib and 4 iden. S	4 iden ; 1 sib
x 2 sib and 3 iden S	2 iden ; 2 pat sib, mat iden to the iden, 1 pat iden. to the iden, mat sib
x 2 sib and 3 iden S	3 iden, 2 pat sib, 1 of which is iden and 1 sib to the iden
x 3 sib and 2 iden S	3 pat sib., mat. iden, 2 pat iden to each other pat sib to the iden 1 mat iden and 1 mat. sib to the iden
x 3 sib and 2 iden S	2 iden, 1 sib, 2 pat sib, mat iden to each other and to iden.
x 3 sib. and 2 iden S	3 iden, 1 pat. sib., mat iden to iden., 1 pat. iden, mat sib. to iden
x 1 4-nuc and 1 sib S	4 iden, 1 sib
x 1 4-nuc and 1 iden S	4 iden
x 1 3-nuc. and 1 2-nuc. S	3 iden, 1 sib, 1 pat sib, mat. iden to the iden, mat sib to all
x 1 2-nuc and 2 iden S	5 iden.
x 1 3-nuc, 1 sib, and 1 iden S	4 iden, 1 sib
x 1 3-nuc, 1 sib, and 1 iden S	3 iden, 1 pat sib to all, mat iden to iden, mat sib to remaining 1, 1 pat iden to iden, mat. sib. to all others
x 2 2-nuc and 1 sib S	1 sib ; 2 sets of 2 iden, each set pat sib to the other, pat iden to remaining 1, mat iden to each other, mat sib to remaining 1
x 2 2-nuc and 1 iden S	2 sets of 2 iden, each set pat sib. to the other, pat iden to remaining 1, mat iden to each other, mat sib to remaining 1
XXI 1 4-nuc and 1 iden ova	
x 5 sib S	5 pat sib, mat iden.
x 5 iden S	5 iden
x 1 sib and 4 iden S	3 iden, 1 pat. sib, mat iden to the iden, mat sib to remaining 1, 1 pat iden to iden, mat sib
x 1 sib and 4 iden S	4 iden, 1 sib
x 2 sib and 3 iden S	3 iden, 2 pat sib, mat iden
x 3 sib and 2 iden S	2 iden., 3 pat sib, mat iden
x 1 4-nuc and 1 sib S	4 iden., 1 pat sib, mat iden
x 1 4-nuc and 1 iden S	5 iden
x 1 3-nuc and 2 sib S	3 iden, 2 pat sib, mat iden
x 1 3-nuc and 2 iden S	5 iden
x 1 3-nuc, 1 sib, and 1 iden S	4 iden ; 1 pat sib, mat iden
x 2 2-nuc and 1 sib S	2 sets of 2 iden, 1 pat sib, mat iden

TABLE 2 (*Continued*)

Genesis	Relationship
x 2 2-nuc and 1 iden S	2 sets of 2 iden , 1 pat iden to 1 set, sib. to other, mat. iden.
XXII. 1 3-nuc and 1 sib. ova	
x 4 sib. S, 1 2	2 iden.; 1 sib , 2 pat. sib , mat. iden to the iden.
x 4 sib S, 1·2	2 iden ; 3 pat sib., mat. iden. to each other, mat sib. to the iden
x 4 iden S, 1·2	1 set 3 iden.; 1 set 2 iden. Each set pat iden., mat. sib to other set
x 4 iden S, 1 2	4 iden ; 1 pat iden , mat. sib
x 1 sib and 3 iden S, 1.2	3 iden.; 1 pat sib , mat iden to the iden , mat. sib. to remaining 1; 1 pat. iden to iden., pat sib. to remaining 1.
x 1 sib. and 3 iden S, 1 2	4 iden , 1 sib.
x 1 sib. and 3 iden. S, 1·2	1 set 3 iden.; 1 set 2 iden.
x 1 sib and 3 iden. S, 1 2	2 sets of 2 iden , each set pat. sib , mat iden to other set; 1 mat sib , pat. iden. to one set, pat. sib to other.
x 2 sib. and 2 iden S, 1.2	3 iden., 1 pat sib , mat iden to iden ; 1 pat. iden , mat. sib to iden
x 1 3-nuc and 1 sib. S, 1:2	4 iden , 1 sib.
x 1 3-nuc and 1 sib S, 1:2	1 set of 3 iden. ;1 set of 2 iden.
x 1 3-nuc and 1 iden S, 1 2	4 iden , 1 pat. iden , mat sib
x 1 3-nuc. and 1 iden. S, 1 2	1 set 3 iden.; 1 set 2 iden. Each set pat. iden , mat. sib. to other set
x 1 2-nuc., 1 sib , 1 iden. S, 1 2	4 iden.; 1 sib.
x 1 2-nuc., 1 sib , 1 iden S, 1 2	1 set of 3 iden., 1 set of 2 iden.
x 1 2-nuc., 1 sib., 1 iden. S, 1 2	2 sets of 2 iden , mat iden.; 1 mat. sib., pat. iden. to one set
XXIII 1 3-nuc and 1 iden ova	
x 4 sib S, 1·2	2 iden ; 3 pat sib , mat. iden
x 4 iden S, 1·2	5 iden
x 1 sib. and 3 iden. S, 1:2	4 iden.; 1 pat. sib , mat iden
x 1 sib. and 3 iden. S, 1:2	1 set 3 iden , 1 set 2 iden. Each set pat. sib , mat. iden to other set
x 2 sib and 2 iden. S, 1:2	3 iden., 2 pat. sib., mat iden.
x 2 sib and 2 iden. S, 1·2	2 sets of 2 iden , each pat sib., mat iden to other set; 1 mat iden , pat. sib.
x 1 3-nuc. and 1 sib S, 1 2	4 iden , 1 pat sib , mat iden
x 1 3-nuc. and 1 sib S, 1 2	1 set of 3 iden ; 1 set of 2 iden Each set pat sib., mat iden to other set
x 1 3-nuc and 1 iden S, 1 2	5 iden.
x 1 2-nuc , 1 sib , 1 iden S, 1 2	4 iden ; 1 pat. sib , mat iden
x 1 2-nuc , 1 sib., 1 iden. S, 1 2	1 set 3 iden ; 1 set 2 iden Each set pat. sib , mat. iden to other set
XXIV. E 3-nuc. and 2 sib. ova	
x 5 sib S	3 pat. sib., mat. iden.; 2 sib
x 5 iden. S	3 iden.; 2 pat. iden. to each other and to iden , mat. sib

TABLE 2 (*Continued*)

Genesis	Relationship
x 1 sib. and 4 iden S	3 iden , 1 pat iden, mat sib to iden , 1 sib
x 1 sib and 4 iden S	2 iden , 2 pat iden to iden, mat sib , 1 pat sib, mat iden to iden
x 2 sib and 3 iden. S	3 iden , 2 sib
x 2 sib and 3 iden S	1 sib , 2 iden , 1 pat sib., mat iden to iden , 1 pat iden to iden, mat sib
x 3 sib and 2 iden S	3 pat sib, mat iden., 2 pat iden, mat. sib.
x 3 sib. and 2 iden S	2 sib ; 2 iden , 1 pat sib, mat iden to iden.
x 3 sib and 2 iden S	2 pat sib, mat. iden., 1 sib., 1 mat. sib, pat iden to remaining 1, 1 mat iden to the 2 mat. iden, pat iden to remaining 1.
x 1 3-nuc and 2 sib S	3 iden , 2 sib.
x 1 3-nuc. and 2 iden S	3 iden , 2 mat sib., pat iden. to all
x 1 3-nuc, 1 sib, 1 iden S	3 iden , 1 sib , 1 mat. sib, pat iden to iden
XXV 1 3-nuc and 2 iden ova	
x 5 sib S	5 pat sib, mat iden
x 5 iden S	5 iden.
x 1 sib and 4 iden S	4 iden , 1 pat sib, mat. iden
x 2 sib and 3 iden S	3 iden , 2 pat sib, mat iden to all
x 3 sib and 2 iden. S	2 iden , 3 pat sib, mat iden to all
x 1 3-nuc. and 2 sib S	3 iden , 2 pat sib, mat. iden to all
x 1 3-nuc and 2 iden S	1 set of 3 iden , 1 set of 2 iden Each set pat sib, mat iden. to other set.
x 1 3-nuc., 1 sib., 1 iden S	4 iden , 1 pat sib, mat. iden to all.
XXVI 1 3-nuc and 1 2-nuc ova	
x 5 sib S	3 pat. sib, mat iden , 2 pat sib., mat iden.
x 5 iden S	1 set of 3 iden , 1 set of 2 iden. Each set pat iden, mat sib to other set.
x 1 sib and 4 iden S	2 sets of 2 iden, pat iden to each other, 1 pat sib, mat iden to one set
x 1 sib and 4 iden S	3 iden , 1 pat sib, mat iden to remaining 1, 1 pat iden. to iden, mat iden to remaining 1.
x 2 sib and 3 iden S	3 iden , 2 pat sib, mat. iden to each other
x 2 sib and 3 iden S	2 iden ; 2 pat sib, mat iden to remaining 1, 1 pat iden to iden, mat iden to other 2
x 3 sib and 2 iden S	2 iden , 2 pat sib, mat iden to each other, 1 pat sib, mat iden to iden
x 3 sib and 2 iden S	3 pat sib, mat iden , 2 iden
x 3 sib and 2 iden S	2 pat sib, mat iden ; 1 pat iden to 1 and pat sib to remaining 2, mat. iden to 2 mat iden , 1 pat. sib, mat iden to remaining 1

TABLE 2 (*Continued*)

Genesis	Relationship
x 1 3-nuc and 2 sib S	3 iden, 2 pat sib, mat iden
x 1 3-nuc and 2 iden S	3 iden.; 2 iden Each set sib to other
x 1 3-nuc. and 1 2-nuc S	3 iden., 2 iden Each set sib to other
x 1 3-nuc., 1 sib., 1 iden S	3 iden.; 1 pat. iden, mat sib to iden, 1 pat sib., mat iden to remaining 1
XXVII 1 3-nuc., 1 sib, 1 iden ova	
x 5 sib S	1 sib., 4 pat sib, mat iden
x 5 iden S	4 iden, 1 pat iden, mat sib
x 1 sib and 4 iden S	4 iden; 1 sib
x 1 sib and 4 iden S	3 iden, 1 pat iden, mat sib to iden; 1 pat sib, mat iden to iden
x 2 sib and 3 iden S	3 iden; 1 sib, 1 pat sib, mat. iden to iden
x 2 sib and 3 iden S	2 iden, 2 pat sib, mat iden to iden, 1 pat. iden to iden., mat sib.
x 3 sib and 2 iden S	2 iden, 1 sib; 2 pat sib, mat iden to iden
x 3 sib and 2 iden. S	3 pat sib, mat. iden, 1 mat iden. to iden, pat. iden to remaining 1, 1 mat sib, pat iden to remaining 1.
x 1 3-nuc, 1 sib, 1 iden S	4 iden, 1 sib.
x 1 3-nuc, 1 sib, 1 iden S	3 iden, 1 pat sib, mat iden to iden, 1 mat sib, pat iden to iden.
XXVIII 2 2-nuc ova	
x 4 sib S, 1.2	2 iden, 2 pat sib, mat iden, 1 pat sib, mat iden to iden
x 4 iden S, 1 2	1 set 3 iden, 1 set 2 iden. Each set pat iden, mat sib to other set
x 1 sib and 3 iden S, 1·2	2 sets 2 iden; 1 pat iden, mat sib to 1 set, pat sib, mat iden to other
x 1 sib and 3 iden S, 1 2	2 sets 2 iden, pat. iden to each other; 1 pat sib, mat iden to 1 set
x 2 sib. and 2 iden S, 1.2	2 sets 2 iden; 1 pat sib, mat iden to 1 set
x 2 sib. and 2 iden. S, 1.2	1 set 3 iden; 2 pat sib, mat iden to each other.
x 2 2-nuc S, 1 2	1 set 3 iden, 1 set 2 iden
XXIX. 2 2-nuc and 1 sib. ova	
x 5 sib. S	1 sib; 2 sets of 2 pat sib, mat iden.
x 5 iden S	2 sets of 2 iden; 1 pat iden, mat. sib to 1 set.
x 1 sib and 4 iden S	2 sets 2 iden, pat iden to each other, 1 sib.
x 1 sib and 4 iden S	2 iden., 2 mat. iden, pat sib, one pat iden to iden and to remaining 1, 1 mat sib, pat iden to iden
x 2 sib. and 3 iden S	2 iden., 1 sib, 2 mat. iden, pat sib, 1 of which pat iden to iden
x 2 sib and 3 iden. S	2 iden, 2 pat. sib., mat iden, 1 mat. sib, pat iden. to iden
x 2 sib and 3 iden S	2 iden., 2 pat sib, mat iden, 1 mat. sib, pat iden. to iden.

TABLE 2 (*Continued*)

Genesis	Relationship
x 3 sib. and 2 iden S	2 pat sib, mat iden., 2 mat iden, pat sib., 1 of which pat iden to remaining 1, 1 mat sib, pat iden to 1 of 2 mat iden, pat sib
x 3 sib and 2 iden S	2 iden, 1 sib, 2 pat sib, mat iden
x 3 sib and 2 iden S	1 sib, 2 sets pat. sib, mat. iden., 1 of each set pat iden to 1 of other set
x 2 2-nuc and 1 sib. S	2 sets 2 iden, 1 sib
x 2 2-nuc and 1 iden S	1 set 3 iden, 1 set 2 iden.
XXX 2 2-nuc. and 1 iden ova	
x 5 sib S	2 pat sib, mat iden, 3 pat sib, mat iden
x 5 iden S	2 inden, 3 iden All pat iden (Or 5 iden)
x 1 sib. and 4 iden S	3 iden; 2 mat iden, pat sib., but 1 pat. iden to iden
x 1 sib and 4 iden S	2 sets of 2 iden, pat iden to each other, 1 mat. iden to 1 set, pat sib.
x 2 sib and 3 iden S	3 iden; 2 pat sib, mat iden
x 2 sib and 3 iden S	2 iden, 2 mat iden, mat sib, 1 of which pat iden to iden., 1 pat sib, mat iden to the non-iden.
x 3 sib and 2 iden S	2 iden.; 2 mat iden, pat sib; 1 pat. sib, mat iden to iden
x 3 sib and 2 iden S	2 iden, 3 pat sib, mat. iden
x 2 2-nuc. and 1 sib S	2 sets 2 iden, 1 pat sib, mat. iden to 1 set
x 2 2-nuc and 1 iden S	1 set 2 iden, 1 set 3 iden
XXXI 1 2-nuc and 1 sib ova	
x 3 sib. S, 1 3	3 iden, 2 mat iden pat sib
x 3 sib S, 1 3	1 sib, 3 iden, 1 pat sib, mat iden to iden
x 3 iden S, 1 3	1 set 3 iden, 1 set 2 iden All pat iden.
x 3 iden S, 1·3	4 iden, 1 pat iden, mat sib
x 3 iden S, 2·2	4 iden, 1 pat iden, mat sib
x 3 iden S, 2 2	1 set 3 iden, 1 set 2 iden All pat iden
x 3 sib S, 2 2	2 sets 2 iden, mat iden to each other, 1 sib
x 3 sib S, 2.2	2 sets 2 iden, 1 pat sib, mat iden. to 1 set
x 1 sib and 2 iden S, 1 3	4 iden, 1 sib
x 1 sib and 2 iden S, 1 3	1 set 3 iden, 1 set 2 iden
x 1 sib and 2 iden S, 2 2	4 iden, 1 sib
x 1 sib and 2 iden S, 2 2	2 sets 2 iden, pat iden to each other, 1 pat sib, mat iden to 1 set iden
x 1 2-nuc and 1 sib S, 1 3	4 iden, 1 sib
x 1 2-nuc and 1 sib S, 1 3	1 set 3 iden, 1 set 2 iden
x 1 2-nuc and 1 sib S, 2 2	4 iden, 1 sib

TABLE 2 (*Continued*)

Genesis	Relationship
x 1 2-nuc and 1 sib S, 2.2	1 set 3 iden, 1 set 2 iden
x 1 2-nuc. and 1 iden S, 1 3	1 set 2 iden.; 1 set 3 iden. All pat. iden
x 1 2-nuc and 1 iden. S, 1 3	4 iden., 1 mat sib, pat iden
x 1 2-nuc and 1 iden. S, 2 2	4 iden, 1 mat sib, pat iden
x 1 2-nuc and 1 iden. S, 2 2	1 set 3 iden, 1 set 2 iden. All pat iden
XXXII 1 2-nuc and 1 iden ova	
x 3 sib. S, 1·3	5 pat. sib, mat iden
x 3 iden S, 1 3	5 iden
x 3 sib S, 2 2	5 pat sib, mat iden
x 3 iden. S, 2 2	5 iden.
x 1 sib and 2 iden S, 1.3	1 set 3 iden; 1 set 2 iden All mat iden.
x 1 sib and 2 iden. S, 1:3	4 iden, 1 pat. sib, mat. iden.
x 1 sib and 2 iden. S, 2.2	4 iden, 1 pat sib., mat. iden
x 1 sib and 2 iden S, 2 2	1 set 3 iden, 1 set 2 iden. All mat. iden
x 1 2-nuc and 1 sib S, 1·3	1 set 2 iden, 1 set 3 iden All mat iden.
x 1 2-nuc. and 1 sib S, 1·3	4 iden., 1 mat. iden, pat sib
x 1 2-nuc and 1 sib S, 2.2	4 iden; 1 sib
x 1 2-nuc and 1 sib S, 2·2	1 set 3 iden., 1 set 2 iden All mat iden
x 1 2-nuc. and 1 iden S, 1.3	5 iden.
x 1 2-nuc. and 1 iden. S, 2.2	5 iden
XXXIII 1 2-nuc, 1 sib, and 1 iden ova	
x 4 sib S, 1.2	1 sib.; 2 iden.; 2 pat sib., mat iden. to iden.
x 4 sib S, 1.2	2 iden, 3 pat. sib., mat iden.
x 4 iden S, 1 2	3 iden., 2 iden. All pat. iden.
x 4 iden S, 1·2	4 iden.; 1 pat iden, mat sib.
x 1 sib. and 3 iden S, 1 2	4 iden,. 1 sib
x 1 sib. and 3 iden. S, 1.2	3 iden, 2 iden
x 2 sib and 2 iden. S, 1·2	3 iden; 1 sib, 1 pat sib, mat iden to iden.
x 2 sib. and 2 iden. S, 1·2	2 sets 2 iden, each mat iden to the other, 1 sib
x 1 2-nuc, 1 sib, 1 iden S, 1 2	4 iden, 1 sib
x 1 2-nuc., 1 sib, 1 iden. S, 1·2	1 set 3 iden; 1 set 2 iden

Reference to the table will disclose that each of the many modes of quintuple genesis does not give rise to a unique relationship among quintuplets Various modes of genetic origin result in common forms of relationships.

In summary, it may be said that there are, perhaps, 206 modes of quintuplet genesis giving rise to 84 distinct types of quintuplet relationships, namely:

1 5 identical
2 5 paternally identical, maternally sibling
3 5 maternally identical, paternally sibling
4 4 identical, 1 sibling
5 4 identical, 1 paternally identical, maternally sibling
6 4 identical, 1 maternally identical, paternally sibling
7 3 identical, 2 identical
8 3 identical, 2 identical All maternally identical
9. 3 identical, 2 identical All paternally identical
10 3 identical; 2 paternally identical, maternally sibling
11 3 identical, 2 maternally identical, paternally sibling
12 3 identical, 2 paternally identical, maternally sibling to all
13 3 identical, 2 maternally identical, paternally sibling to all.
14 3 identical, 2 sibling.
15. 3 identical, 1 sibling, 1 maternally sibling, paternally identical to the identical
16. 3 identical, 1 sibling, 1 paternally sibling, maternally identical to the identical.
17 3 identical, 1 paternally identical, maternally sibling to the identical, 1 paternally sibling, maternally identical to the identical
18 3 identical, 1 paternally identical, maternally sibling to the identical, 1 sibling
19 3 identical, 1 paternally identical to the identical, maternally identical to the fifth, 1 paternally sibling, maternally identical to the fifth
20 3 identical, 1 paternally identical to the identical, maternally sibling, 1 paternally sibling, maternally identical to the identical
21 2 identical, 2 identical, 1 sibling
22 2 identical; 2 identical, 1 sibling Each set of identical paternally identical, maternally sibling to other set.
23 2 identical; 2 identical; 1 sibling Each set of identical maternally identical, paternally sibling to other set
24 2 identical, 2 identical, 1 maternally identical to one set of identical
25 2 identical, 2 identical; 1 paternally identical to one set of identical.
26 2 identical, 2 identical. Each set paternally identical to other set. 1 paternally identical, maternally sibling to all.
27 2 identical; 2 identical Each set maternally identical to other set 1 maternally identical, paternally sibling to all
28 2 identical, 2 identical Each set paternally identical to other set 1 paternally identical to one set

29 2 identical, 2 identical Each set maternally identical to other set 1 maternally identical to one set
30 2 identical; 2 identical Each set paternally identical to other set. 1 maternally identical to one set
31 2 identical; 2 identical Each set maternally identical to other set 1 paternally identical to one set
32 2 identical, 2 sibling, 1 maternally sibling, paternally identical to identical
33. 2 identical, 2 sibling, 1 maternally identical, paternally sibling to identical
34. 2 identical, 1 sibling, 2 paternally sibling, maternally identical to the identical
35. 2 identical, 1 sibling; 2 paternally identical, maternally sibling to the identical
36. 2 identical, 1 sibling, 2 paternally identical to each other, maternally sibling.
37. 2 identical, 1 sibling, 2 maternally identical to each other, paternally sibling.
38. 2 identical; 1 sibling, 2 maternally identical, paternally sibling, 1 of which is paternally identical to the identical.
39 2 identical, 1 sibling, 2 paternally identical, maternally sibling, 1 of which is maternally identical to the identical
40. 2 identical, 1 sibling, 2 maternally identical, paternally sibling, 1 of which is maternally identical to the identical.
41. 2 identical, 1 sibling, 2 paternally identical, maternally sibling, 1 of which is paternally identical to the identical
42. 2 identical, 1 sibling, 1 paternally sibling, maternally identical to the identical, 1 paternally identical to the identical, maternally sibling
43. 2 identical; 2 paternally identical, maternally sibling; 1 paternally identical to the identical, maternally sibling
44. 2 identical, 2 paternally identical, maternally sibling, 1 maternally identical to the identical, paternally sibling
45 2 identical, 2 maternally identical, paternally sibling, 1 paternally identical to the identical, maternally sibling
46. 2 identical, 2 maternally identical, paternally sibling; 1 maternally identical to the identical, maternally sibling
47 2 identical, 2 paternally identical, maternally sibling, 1 paternally identical to the non-identical
48 2 identical, 2 maternally identical, paternally sibling; 1 maternally identical to the non-identical
49 2 identical; 2 paternally identical to the identical, maternally sibling; 1 paternally sibling, maternally identical to the identical

50 2 identical; 2 maternally identical to the identical, paternally sibling; 1 maternally sibling, paternally identical to the identical

51 2 *identical, 2 paternally identical, maternally sibling*, 1 paternally identical to the non-identical

52 2 identical, 2 maternally identical, paternally sibling, 1 maternally identical to the non-identical.

53. 2 identical, 2 paternally identical, maternally sibling, 1 paternally identical to the non-identical and maternally identical to the identical

54 2 identical, 2 maternally identical, paternally sibling, 1 maternally identical to the non-identical and paternally *identical to the identical*

55 2 identical, 2 paternally identical, maternally sibling to the identical; 1 maternally identical to the identical, paternally identical to the non-identical

56 2 identical, 2 paternally identical, maternally sibling to the identical, 1 maternally identical to the identical, paternally identical to the non-identical

57 2 identical; 2 maternally identical, paternally sibling to the identical, 1 paternally identical to the identical, maternally identical to the non-identical

58. 2 identical, 2 paternally identical, maternally sibling to the identical; 1 paternally identical to the identical, maternally identical to the non-identical.

59 2 identical, 2 maternally identical, paternally sibling to the identical, 1 maternally identical to the identical, paternally identical to the non-identical

60 2 identical, 2 maternally identical, paternally sibling, 1 of which is paternally identical to the identical, 1 paternally sibling, maternally identical to the non-identical

61 2 identical; 2 paternally identical, maternally sibling, 1 of which is maternally identical to the identical, 1 matternally sibling, paternally identical to the non-identical.

62 2 identical, 3 paternally identical, maternally sibling

63 1 sibling, 4 paternally identical, maternally sibling.

64 1 sibling; 4 maternally identical, paternally sibling

65 1 sibling, 2 paternally identical, maternally sibling, 2 paternally sibling, maternally identical

66. 1 sibling; 2 paternally identical, maternally sibling, 2 paternally identical, maternally sibling

67. 1 sibling, 2 maternally identical, paternally sibling, 2 maternally identical, paternally sibling

68 1 sibling, 2 paternally identical, maternally sibling; 1 paternally identical to set of 2, maternally identical to fifth, 1 paternally sibling, maternally sibling to set of 2, maternally identical to remaining 1

69 1 sibling; 2 paternally sibling, maternally identical, 1 maternally identical to set of 2, paternally identical to fifth, 1 maternally sibling, paternally identical to remaining 1

70 1 sibling, 2 sets of 2 paternally sibling, maternally identical, 1 of each set paternally identical to 1 of other set

71 1 sibling, 2 sets of 2 maternally sibling, paternally identical, 1 of each set maternally identical to 1 of other set

72 2 sibling, 3 paternally identical, maternally sibling

73 2 sibling, 3 maternally identical, paternally sibling

74 3 sibling; 2 paternally identical, maternally sibling

75 3 sibling, 2 maternally identical, paternally sibling

76 3 paternally identical, maternally sibling, 1 paternally identical to set of 3, maternally identical to fifth, 1 paternally sibling, maternally sibling to set of 3, maternally identical to remaining 1.

77 3 paternally identical, maternally sibling, 2 paternally identical, maternally sibling

78. 3 maternally identical, paternally sibling, 2 maternally identical, paternally sibling

79 3 paternally identical, maternally sibling; 2 paternally sibling, maternally identical

80. 3 maternally identical, paternally sibling; 2 maternally sibling, paternally identical

81 3 paternally identical, maternally sibling; 2 maternally identical, 1 of which is paternally identical to set of 3.

82. 3 maternally identical, paternally sibling; 2 paternally identical, 1 of which is maternally identical to set of 3

83 2 paternally sibling, maternally identical, 2 paternally sibling, maternally identical, 1 of which is paternally identical to fifth, 1 maternally sibling, paternally identical to 1 of the two sets.

84 2 paternally sibling, maternally identical, 2 paternally identical, maternally sibling, 1 paternally identically sibling identical, maternally sibling; 1 paternally identical, maternally sibling to 1 set, paternally sibling, maternally identical to other set.

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LES RELATIONS GÉNÉTIQUES POSSIBLES ENTRE CINQ JUMEAUX

(Résumé)

En général, on peut grouper toutes les théories de la genèse des jumeaux en quatre catégories, à savoir, celles ayant rapport' (1) à l'ovulation et à la maturation du sperme; (2) à la fertilisation, (3) à la fissure de l'oeuf, et (4) aux caractères des chromosomes. Les facteurs qui se trouvent à la base de ces théories fonctionnent sans doute dans la production de tous les types des enfants multiples. Ainsi une cellule sexuelle femelle ou plus peut être fertilisée, et dans une ou plus de celles-ci la division peut avoir lieu ou avant ou après la fertilisation. Par conséquent, les diverses cellules sexuelles femelles qui comprennent la genèse des enfants multiples seront identiques ou fraternells à l'égard les unes des autres. De même façon les cellules mâles aussi représenteront une relation fraternelle ou identique les unes aux autres Donc les enfants multiples peuvent être paternellement identiques ou paternellement fraternels selon qu'ils sont fertilisés par des spermatozoïdes identiques ou fraternels respectivement De même façon, les enfants peuvent être maternellement identiques ou maternellement fraternels selon qu'ils sont développés d'oeufs identiques ou d'oeufs fraternels respectivement

Quand on classifie tous les types possibles de genèse de 5 jumeaux dans les cellules germinatives et qu'on déchiffre tous leurs moyens possibles de fertilisation, il se montrera que chaque moyen de genèse de 5 jumeaux ne cause pas une relation unique entre 5 jumeaux Divers moyens d'origine génétique résultent en formes communes de relations. En somme il y a peut-être deux cent six moyens de genèse de 5 jumeaux qui causent quatre-vingt-quatre types distincts de relations de 5 jumeaux

SCHEIDEMANN

MÖGLICHE GENETISCHE BEZIEHUNGEN ZWISCHEN FÜNFLINGEN

(Referat)

Im allgemeinen konnen alle Theorien uber Zwillingsgenese in vier Kategorien eingeordnet werden, namlich (1) in diejenigen, die sich auf Eier- und Samenerzeugung beziehen, (2) Befruchtung, (3) Eispaltung, und (4) Eigenschaften der Chromosomen Die Faktoren, die diesen Theorien unterliegen, funktionieren zweifellos bei der Erzeugung aller Arten von vielfacher Nachkommenschaft Auf diese Weise konnen eine oder mehr Geschlechtszellen befruchtet werden, und in einer oder meheren dieser kann eine Spaltung entweder vor oder nach der Befruchtung vorkommen Folglich werden die verschiedenen weiblichen Geschlechtszellen, die die Genese der Vielfachen Nachkommenschaft aussmachn, identisch oder

blutverwandt in bezug aufeinander sein Ahnlicherweise werden die mannlichen Zellen auch ein blutverwandtes oder identisches Verhaltnis miteinander darstellen Folglich kann die vielfache Nachkommenschaft vaterlich identisch oder vaterlich blutverwandt sein, je nachdem sie von identischen oder blutverwandten Samen befruchtet werden Gleicherweise konnen die Nachkommenschaft mutterlich identisch oder mutterlich blutverwandt sein, je nachdem sie sich aus identischen oder blutverwandten Eiern entwickeln.

Wenn alle moglichen Arten von funffacher Keimzellengenese aufgeschrieben werden und alle moglichen Arten ihrer Befruchtung entziffert, so wird dargelegt, dass jede Art der funffachen Genese nicht ein einzigartiges *Verhaltnis unter Funflingen entstehen lasst Verschiedene Arten des* genetischen Ursprungs ergeben gemeinsame Formen der Verhaltnisse Zusammenfassend gibt es vielleicht zweihundertundsechs Arten der funffachen Genese, welche vierundachtzig bestimmte Arten von funffachen Verhaltnissen entstehen lassen.

SCHEIDEMANN

A PRELIMINARY STUDY OF THE EIDETIC IMAGERY OF PRESCHOOL CHILDREN*

From the Psychological Laboratory of the University of Texas

LEIGH PECK AND ROSEMARY WALLING

The investigation to be reported is an experimental study of the visual eidetic imagery of preschool children. As far as the writers know, it is the first such study to be made either in the United States or abroad.

Eidetic images are experienced with sensory clearness, the visual eidetic image is literally seen. In consideration of the numerous careful studies that have been made with adults and with children of school age, there is no reason to doubt the existence of visual eidetic phenomena. These are believed by Jaensch (9) to be ten times as common as acoustic eidetic images.

PREVIOUS STUDIES

To the Marburg school of psychologists in Germany, under the leadership of E. R Jaensch, belongs the credit for arousing interest in eidetic phenomena and for making extensive investigations[1] of visual eidetic imagery. Their experimental work has been done with children of school age and with adults Jaensch himself commonly chose subjects at least ten years old (9). Roessler (19) examined children between six and ten years of age, his subjects are the youngest reported in any systematic investigation

Allport (1) examined children from ten to 15 years old; Teasdale's (21) subjects were between ten and 14; Kluver (11, 15, 16) mentions no subjects younger than 11 years; Meenes (18) worked with children of school age; Gengerelli's (7) subjects were two girls of 11 and 15 respectively; Drummond (6) used chiefly adult psychology students, Tripp (22) tested children of 12 to 15.

Antipoff (3) reported the spontaneous eidetic imagery of her seven-year-old son, and Révész (19) described the after-images of his preschool daughter. Downey (5) related the case of a four-

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[1]The most complete summaries available in English are those by Kluver (10-14, 17)

year-old boy who, though he was given no systematic examination, showed indications of spontaneous eidetic imagery This child is the youngest reported in the literature concerning eidetic phenomena

In testing children between six and ten years of age, Roessler (20) found no correlation, either positive or negative, between eidetic ability and general intelligence, his conclusion is in harmony with those of other investigators He found eidetic phenomena in 40 per cent of his subjects, with no significant sex differences Reports of sex differences by other writers have been conflicting and inconclusive

Differences between Older and Younger Children

Whether younger children differ from older children and from adults in the characteristics of their images is an interesting question. Eidetic imagery is found much more frequently among children than adults But at what period in childhood is it most frequently found and most vivid? Some writers have maintained that eidetic ability is greatest just before puberty. Allport (1) considers the period between 12 and 15 most favorable Jaensch (9), however, believes that eidetic phenomena are more frequently found in younger children; and his contention is supported by Roessler's study (20), which indicates that eidetic ability is greater at six years than at the higher age levels. Teasdale (21), using subjects ten to 14 years old, found that frequency of eidetic imagery increases with age if the weaker forms of imagery are included, but that stronger imagery is present in the younger children

It is possible that younger subjects differ from older subjects with respect to the colors in which the images appear. Allport (1), testing children between 10 and 15, states that positive eidetic images are characteristic of the younger subjects, but that older subjects tend to see eidetic images in colors complementary to those of the stimulus object Roessler's (20) subjects often experienced images that were neither positive nor negative. For example, the eidetic image of a black silhouette picture might be red or green or purple.

Herwig (8) reports that of 30 boys whose after-images he studied, only 10 (average age, 15 years) had negative after-images, while 20 (average age, 13 years) had positive after-images. Of those who were classed as having negative after-images, some still experienced positive images of red and green stimuli even though

their images of yellow and blue stimuli were negative G. W. Allport (2) mentions an unpublished study by A L Allport, in which 43 children (average age, 11 years) were found to have negative after-images, 11 children (average age, 11 years) achromatic after-images, and nine children (average age, nine years) positive after-images

Nature of Eidetic Images

Eidetic images occupy a position intermediate between after-images and memory images They differ from after-images in that they are commonly seen without fixation, are of more complex detail, may in some individuals be changed in detail, banished, or summoned, at the will of the observer, are sometimes seen in three dimensions; and are seen in positive colors by some individuals who see after-images in complementary colors. Moreover, eidetic images are said not to conform to Emmert's law, that is, they do not increase in size as the distance of the projection screen from the subject is increased Jaensch (9) considers positive after-images an indication of eidetic ability After-images of long duration and after-images that are continuous, not coming and going intermittently, are also considered by Jaensch to be signs of eidetic ability.

Eidetic images differ from memory images in that they are outwardly projected, literally seen. The subject, as he watches the projection screen, may exclaim, "Now I see it. Now it's gone. Now it's coming back!" Very often the eidetic image is richer in detail than the memory image.

The determination of whether a subject is describing an after-image, an eidetic image, or a memory image is, of course, a crucial point in testing for eidetic imagery The distinction is perhaps more difficult to make when the experimenter is working with very young subjects. Jaensch (9) has suggested that in young children, tending toward the "unitary type," the after-image, the memory image, and the eidetic image may be more closely related to each other, and more closely related to the perceptual processes, than is the case with adults In distinguishing between after-images and eidetic phenomena, the experimenter should note whether the subject fixates upon the stimulus picture, or whether he moves his eyes freely inspecting it. In distinguishing eidetic phenomena from memory images, the experimenter should note whether the "attention of the subject is directed outwards," with an "attitude of external localiza-

tion," as Allport (1) says, and whether "eye tension" is present when the subject looks at his projected image on the screen, as Teasdale (21) observes

The eidetic image depends both upon a physiological element, in so far as it resembles an after-image, and upon a conceptual element in so far as it resembles a memory image (9). In selecting pictures to be used in testing for eidetic imagery, both elements must be considered. The physiological conditions are satisfied by the selection of pictures with simple, strong outlines; in most of the investigations, silhouette pictures have been used, sometimes (as by Teasdale) with the main figures in black and the background in colors The conceptual conditions are satisfied by the selection of interesting, meaningful, rather complex pictures. In testing children, it is especially important to use pictures that attract the involuntary attention of the subject

In some subjects, the physiological element dominates the eidetic image, so that it more nearly resembles an after-image, in other subjects, the conceptual element dominates the eidetic image, so that it more nearly resembles a memory image Jaensch (9) refers to subjects in whom the physiological element dominates as the T-type, because he thinks their reaction related to a calcium deficiency, which in its extreme degree is manifested in tetany He calls the subjects in whom the conceptual element dominates the B-type, postulating in them a hyperthyroid condition, which in its extreme form becomes Basedow's (or Graves's) disease His assumption of these two contrasted personality types as the cause of the observed differences in eidetic imagery has been by no means completely substantiated by controlled investigation

Purpose of Experiment

The purpose of the present experiment was to determine whether the technique of testing for eidetic imagery could be succssfully adapted for use with preschool children. The experiment was undertaken as a preliminary study, with the intention of making more extended investigations if a satisfactory technique could be worked out

The investigators recognized the difficulty of making the test intelligible to such young children, and the further difficulty of securing reliable introspective reports from such young subjects However, children of preschool age can report accurately upon many

everyday matters, and in nursery schools it is customary to rely upon the children's reports in carrying out the daily routine For example, children in nursery school can remember at 12:30 whether or not they brought their pajamas with them at 8 30 They can often even tell who had a toy first, in cases of dispute when the temptation to inaccuracy is great. Moreover, in the fitting of glasses for preschool patients, the oculist must rely upon the child's introspective report. If we can make a test for eidetic imagery intelligible to preschool children, we may expect from them reports comparable in accuracy to the reports of older children The need of investigation with preschool children is evident from the fact that eidetic imagery has been found more frequently and in stronger degree among six-year-olds than among older children (20)

Subjects and Procedure

The subjects used in the present investigation were 20 children from the University of Texas Nursery School. Eighteen were enrolled at the time tested; two were former pupils. They ranged in age from 24 months to 64 months, the median age was 43½ months. Both investigators were well known to the children [2] The subjects were tested individually in a plainly furnished examination room familiar to the children No head rest was used. The child and the examiner (Peck) were seated on opposite sides of a low dull-finished table. The record-keeper (Walling) sat behind the child The light came from windows at the back and to the left of the subject. Time was recorded with a stop watch.

The pictures used in testing were arranged in the order in which they were to be presented to the child, with sheets of gray paper between the mounted pictures. After a picture had been exposed, it was slipped aside and a sheet of gray paper was left in place to serve as a projection screen. The pictures and the projection screen were held by the examiner about fifteen inches from the subject. The objects were mounted on cardboard and exposed in front of the projection screen.

Materials

Two series of test materials were used. A period of several days

[2] Dr Peck as psychologist and Miss Walling as research assistant in the nursery school

intervened between the first and the second testing. The pictures used in the first test series, though rather strongly outlined, were not of the silhouette type, and were possibly more difficult than silhouette pictures because they did not appeal so strongly to what Jaensch calls the "physiological component" of the eidetic images The stimulus-pictures and objects included:

1. *First Test Series*
   a Tests for after-images
      1) Two-inch red square to be fixated 10 seconds.
      2) Two-inch red square to be fixated 20 seconds
      3) Seven-inch black silhouette of boy running, to be fixated 15 seconds
   b. Tests for eidetic imagery
      1) Picture in colors (5x6½ inches) of child mailing letter, street details in background, to be examined without fixation 20 seconds
      2) School scene in colors (5x6½ inches), in foreground children arranging flowers in vase, in background child placing posters on wall, to be examined without fixation 20 seconds
      3) School scene in colors (5x6½ inches), in foreground children examining books, in background child writing on board and teacher assisting pupil, to be examined without fixation 20 seconds.
      4) Red fire truck (3 inches long, 1¼ inches high, 1 inch wide, one wheel off, two firemen, to be examined without fixation 15 seconds.
      5) Silver airplane (4 inches long, 1¼ inches high, 5 inches across wings), three purple propellers, one broken, to be examined without fixation 15 seconds
2. *Second Test Series.*
   a. Tests for after-images.
      1) Two-inch red circle, to be fixated 20 seconds.
      2) Three-inch black silhouette of bear, to be fixated 20 seconds.
   b Tests for eidetic imagery
      1) Black silhouette (3½x4¾ inches) of two children and witch in forest—copy of picture used by Roessler (20)—to be examined without fixation 30 seconds.

2) Black silhouette ($3\frac{1}{2}$x$4\frac{3}{4}$ inches) of girl reading, room detail in background—copy of picture used by Roessler (20)—to be examined without fixation 30 seconds
3) Silhouette in black and red (4x5 inches) of boy picking flowers, girl carrying flower basket and umbrella, to be examined without fixation 30 seconds.

Directions to Subjects

The children were invited to the examination room by the examiner "to look at pictures." All came willingly. Before the test, the examiner, in a preliminary discussion, attempted to explain to the child the possibility of seeing things not really present After the child was seated at the table, he was asked, "Do you know that sometimes we can see things that are not really there?" Since nearly all the children had recently attended a circus, the examiner generally proceeded, "When you think about the elephant at the circus, can you see him, see just how he looked? Can you look up here (at projection screen), and see him right here?" If the child had not attended the circus, he was asked, "Can you think about your mother (or baby sister), and see her?" If the child said he could not "see" the things he was thinking about, he was told, "Maybe you could learn Wouldn't that be fun?" Most people can learn to fixate well enough to experience after-images

After the preliminary discussion, the examiner said, "Now I'm going to show you some pictures. I'll show you one for just a little while, then take it away, and we'll find out whether you can still see it after I take it away." Jaensch (9) suggests telling the child that "something must be seen," but in the present investigation so positive a suggestion to the subject was avoided.

In testing for after-images the examiner said, "I'm going to show you a colored block (or ball). Look right at the dot in the middle of it. Look at it hard. Don't look at anything else. Just look at the dot as long as I show you the picture [Stimulus-picture removed.] Now can you see anything? What do you see? What shape is it? What color is it? Can you put your finger on it? Can you run your finger around the edge and show me how big it is? Is it still there, or is it gone?" The last named question was asked frequently, and was, in practice, interpolated repeatedly between the other quest tions. Moreover, the child's expression and attitude were closely

watched to note whether he really appeared to be looking at something externally projected

In testing for the after-image of a simple silhouette, the examiner said, "Now I'm going to show you a real picture Look at it the way you did at the block (or ball) Look at it hard, and don't look at anything else Look right at the boy's hand (or the bear's eye) [Stimulus-picture removed] Can you see anything now? What do you see? What color is it? What is he doing? Is it still there, or is it gone?"

Short rest periods were given between pictures. Before the testing for eidetic imagery was begun, the examiner explained, "There will be lots of things to see in this picture. Look at all the things in it. Look around at everything in the picture" After the stimulus picture was removed, the examiner asked, "Do you see anything? What do you see?" and then asked such other questions as the child's answers suggested; for example, "What color is the girl's coat? What is she doing? What else do you see? Do you still see something, or is it gone?"

The suggestibility of the subjects was studied by comparing the answers to the question, "Is it still there, or is it gone?" with the answers to, "Is it gone, or is it still there?" The children did not appear to echo the answer last suggested If the subject did not report an image immediately after the removal of the stimulus-picture, he was told, "Keep looking Maybe in a moment you will see it." For some individuals there is a short "latent period" between the removal of the stimulus and the appearance of the image If the subject did not report any images with eyes open, one picture was re-exposed, and the subject was instructed to close his eyes after the removal of the picture, to determine whether an eidetic image could be obtained under these conditions

Records

The time-keeper recorded everything the subject said, and noted also the explanations and questions given by the examiner The duration of an image was considered to be the time elapsed between the child's first report of the image and his report of its disappearance In only one case was the image said to disappear and then to reappear In analyzing the records to find the number of details enumerated in an eidetic image, the investigators counted as details

(1) objects, (2) colors, (3) action, (4) spatial orientation. The subject was not credited with having an eidetic image unless details could be pointed out. This is a more rigid interpretation than that sometimes given by previous investigators, some of whom (12) have regarded the report of colors without detail as an indication of eidetic imagery of a weak or "latent" type.

Results

After-Images. In the first test series, after-images were reported by 11 (55 per cent) of the 20 subjects, and in the second test series, by 17 (85 per cent) of the subjects. Every child who experienced after-images in the first test also reported them in the second test. At the time of the second series, the examiner demonstrated the technique of fixation to those children who had failed to get after-images in the first series. The demonstration seemed to impress the children with the fact that "you have to look right at it all the time," and six of those who had failed to fixate steadily enough to get after-images in the first testing succeeded in the second series. The only children failing to get after-images in the second testing were a very near-sighted little girl, and two boys under three years of age whose attention was at best rather fluctuating.

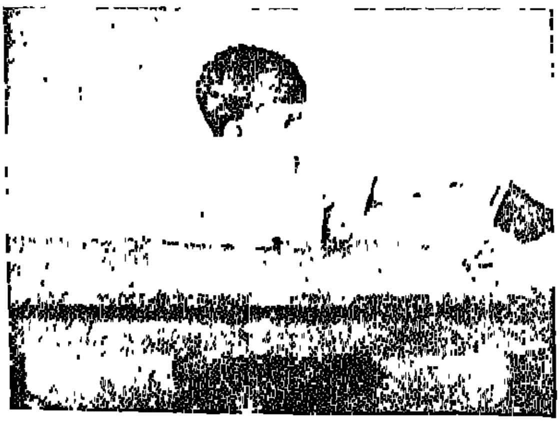

FIGURE 1

Locating Details on Blank Screen

FIGURE 2
POINTING OUT DETAILS OF PROJECTED IMAGE

FIGURE 3
EXAMINING DETAILS OF IMAGE

TABLE 1

INCIDENCE AND CHARACTERISTICS OF AFTER-IMAGES

Subject	Age (Months)	IQ	First series (1) Time	First series (1) Color	First series (2) Time	First series (2) Color	First series (3) Time	First series (3) Color	Second series (1) Time	Second series (1) Color	Second series (2) Time	Second series (2) Color
1	24	138							5	+	28	+ Blue
2	32	138			26	+	14	+	13	+	28	Green
3	33	97										
4	34	116										
5	36	127	15	White	21	+	32	+	34	—	34	+
6	37	133							150	White	135	+
7	39	110							17	+	12	+
8	42	125	68	—	40	—	23	Green	12	—	46	+
9	43	121							25	+		
10	43	142	154	Black White	75	Black	35	+	59	+	37	+
11	44	104							44	+	100	Green
12	44	122							16	— Brown	7	+ Brown
13	45	126	103	+ Blue	70	+ Black	35	+ Red	15	+	8	+
14	46	129	24	+	10	Blue	10	+	9	+	14	?
15	48½	111			41	Brown	23	Brown	30	+ Blue	19	Red
16	50	112										
17	51	117	54	+	38	+	21	+	27	+	27	+
18	58½	107	40	+	59	+	41	+	31	+	31	+
19	58	115	423	+	omitted		300	Gray Brown White Yellow	559	— Yellow	673	—
20	64	128	46	+	57	+	44	+	46	+	50	+
Average	43½	121	103		43		52		64		78	

Table 1 summarizes the data concerning the after-images of the individual subjects. The intelligence quotients given are from tests with the Minnesota Preschool Scale The duration of each image is stated in seconds. Positive coloring is represented by the plus sign (+), and negative coloring by the minus sign (—). Colors other than positive or negative are given by name. In cases where the image changed in color, the changes are indicated in order of occurrence

Table 2 summarizes the data concerning the duration and coloring of the after-images The fact that two-thirds of the images were positive, and nearly one-fifth in colors other than positive or negative, indicates the possibility that these were really eidetic images and not true after-images Jaensch (9) suggests that young children tend toward the "unitary type" with eidetic images and after-images closely related to each other. The question of whether the subjects were familiar with the names of colors must be considered, especially since the naming of colors is placed at five years by the Stanford-Binet (which is generally, however, considered too easy at the preschool levels) The children's knowledge was checked with the color tests from the Minnesota Preschool Scale (Forms A and B) and was found to be accurate to the extent that each child who reported an after-image or an eidetic image knew the stimulus color and knew accurately whatever color he reported in his image. In nursery school, the children's attention had been rather frequently directed to the naming of colors

Eidetic Images. Ten children (50 per cent of the groups) reported eidetic images in the first test series, and only the same ten reported such images in the second series None of the six children who, in the second testing, learned to fixate for after-images reported eidetic images All the eidetic subjects looked at their projected images on the screen None of the subjects who failed with eyes open succeeded in getting an image by closing the eyes after the removal of the stimulus Table 3 summarizes the data concerning the eidetic images of the individual subjects

Table 4 summarizes the data concerning the duration, the details, and the coloring of the eidetic images The images resulting from the presentation of stimulus-objects did not differ significantly from those resulting from stimulus-pictures; consequently, the data concerning all the eidetic images are combined in the table.

TABLE 4

SUMMARY OF DATA CONCERNING EIDETIC IMAGES

	Number of eidetic images	Duration (seconds)		Number of details		Coloring (Percentage of images)			
		Range	Average	Range	Average	Positive	Negative	Achromatic	Other colors
First series (colored pictures)	39	3-300	53	1-12	4.6	98		2	
Second series (detailed silhouettes)	24	15-431	56	1-13	4.8	88	4		8

Reliability of Technique

The reliability of the technique used may be evaluated: (1) by noting the consistency with which the two parts of the test distinguish the *eidetic from the non-eidetic subjects, and* (2) by *correlating* the ranking of the eidetic subjects in the first test series with their ranking in the second test series. The test is consistent in distinguishing the eidetic from the non-eidetic subjects, as the same ten children reported eidetic phenomena in each test series

The relative ranking of the ten eidetic subjects may be determined by either of two criteria: the total number of details reported in the images, or the total duration of the images These two methods of ranking the subjects correlate quite highly with each other. In the first test series, the correlation between number of details and duration of images is 95±.02; in the second series, 88±.04. However, richness of detail is generally considered the best criterion of the strength of eidetic imagery (12)

When number of details is used as the criterion for ranking the eidetic subjects, the correlation between the first test series and the second is 75± 09 When duration of images is used in ranking the subjects, the correlation between the two parts of the test is 48±.16 The correlations between the parts of the test are summarized in Table 5

TABLE 5
Correlations Between Parts of Test
(10 eidetic subjects)

1st variable	2nd variable	r PE_r
(1) Number of details in *first series*	(1) Duration of images *in first series*	95± 02
(2) Number of details in second series	(2) Duration of images in second series	88± 94
(3) Number of details in first series	(3) Number of details in second series	75± 09
(4) Duration of images in first series	(4) Duration of images in second series	48± 16

Correlations with CA and MA

The number of subjects in the present experiment is too small to permit any statistical comparisons of the incidence and richness of eidetic imagery at the various preschool age levels However, the correlation between chronological age, and either number of de-

tails reported or duration of images, is positive, as indicated in Table 6. While the figures based on so small a number of subjects can be only suggestive, it is interesting to note that the correlations with age are decidedly lower for the second test series than for the first series or for the total test. The second series of stimuli consisted of silhouette pictures that appealed more strongly to what Jaensch calls the "physiological component" in eidetic imagery than did the stimuli used in the first series. Perhaps this "physiological" factor in eidetic imagery is less dependent on age than is the "conceptual component" also mentioned by Jaensch.

TABLE 6
CORRELATIONS OF EIDETIC IMAGERY WITH AGE
(10 eidetic subjects)

	Chronological age with: Details	Chronological age with: Time	Mental age with Details	Mental age with Time
First series	.55±.14	.41±.17	.74±.09	.70±.10
Second series	.17±.21	.00	.56±.14	.32±.18
Total test	.41±.17	.43±.17	.74±.09	.72±.10

The correlation between mental age and either number of details reported or duration of images is also positive, and is lower for the second test series than for the first series or for the total test. Experimenters using older children and adults as subjects have found no correlation between general mental ability and eidetic imagery. However, differences in mental age may affect the performance of very young children in a test for eidetic imagery more than similar differences would affect the performance of older subjects. A certain minimum of mental ability is necessary in order to keep the directions in mind and to concentrate attention on the task.

COMPARISON OF PRESCHOOL WITH FIRST-GRADE GROUP

A comparison of the preschool with a first-grade group was made possible through the cooperation of Miss Mary Clare Petty,[8] who used the first series of test material with 45 first-grade pupils. Her subjects averaged 80 months of age, 36.5 months older than the preschool group. After-images were reported by 86.6 per cent of her subjects, as compared with 55 per cent of the preschool subjects (85 per cent of whom, however, reported after-images on the sec-

[8]Miss Petty's study, now in progress, is an investigation of certain factors (including eidetic imagery) affecting the reading readiness of first-grade children.

ond testing) The duration of the images was decidedly longer for the preschool group, 66 seconds as compared with 14 seconds While the majority of the after-images reported by the preschool children were positive, nearly all the first-grade children reported negative images Positive and achromatic images were, however, mentioned by a few of the school group

As indicated in Table 7, 42.2 of the first-grade children reported eidetic imagery The figure corresponds closely to that (40 per cent) found by Roessler for children of six to ten years. It is slightly exceeded by the preschool group, 50 per cent of whom reported eidetic imagery Of the 19 eidetic subjects in the first grade, only seven were able to project all their images on the screen; nine experienced all their images, and three part of their images, with eyes closed The duration of the images was longer for the preschool subjects, 53 seconds as compared with 26, and the number of details enumerated was slightly greater, 4.6 as compared with 4.1. In both groups the coloring was positive, except for a very few achromatic images.

Individual Variations

There was wide individual variation, both in the duration of the eidetic images and in the number of details reported Among the first-grade children, the range for time was from 2 to 105 seconds, and for details from one to eight. Among the preschool children, for the same test series, the range for time was from 3 to 300 seconds, and for details from one to twelve

The best individual subject in either group was a child 58 months old, preschool subject number 19 (in Tables 1 and 3) In the first testing, her first after-image lasted 423 seconds; the second stimulus for after-images was omitted, the third after-image was interrupted at the end of 300 seconds, and the child's attention distracted, to avoid undue fatigue. Her first eidetic image in this series was also arbitrarily interrupted at the end of 300 seconds; the others lasted 151, 132, 150, and 78 seconds. The details of the eidetic images numbered 11, 12, 10, 5, and 8, respectively

In the second testing, no interruptions were made, and, although the subject showed fatigue, she insisted that she wanted "to see all the pictures" Short rest periods were given Her two after-images lasted 559 and 673 seconds, and the three eidetic images 431, 67, and 221 seconds The details of the eidetic images numbered

TABLE 7

COMPARISON OF PRESCHOOL WITH FIRST-GRADE GROUP
(First test series)

A After-images

Group	Number	Average age (months)	Percentage reporting after-images	Average duration (seconds)	Coloring
Preschool	20	43½	55*	66	Majority of images positive
First grade	45	80	86.6	14	Majority of images negative

B Eidetic Images

Group	Number	Average age (months)	Percentage reporting eidetic images	Average duration (seconds)	Average number of details	Coloring
Preschool	20	43½	50	53	4.6	Positive except for achromatic image of one subject
First grade	45	80	42.2	26	4.1	Positive except for achromatic images of three subjects

*85 per cent of the preschool group reported after-images in the second test series

13, 10, and 8, respectively The coloring of the after-images varied, including positive, negative, and also other colors The eidetic images were all positive, except for the introduction of green in one image of a black silhouette Her reactions to tests for Emmert's law also varied. Both after-images and eidetic images seemed to function contrary to Emmert's law when first seen, but to follow Emmert's law as they became weaker.

The definite way in which she enumerated details and pointed them out on the blank screen on which she was projecting her image is indicated by the following quotation from the records made at the time of the test.

> Yes, I can see it It's black and white Two little boys and one man, a tree and a bird, and some leaves and grass. (Color of boys?) Black (Where is old man?) He's on the steps He has his hat on (Still see bird?) Yes, he's sitting on the tree right there (pointing) (Leaves?) One here and one here and here and one here (pointing) (How does children's hair look?) It's straight, with one little curl on each one's head, right here (pointing).

The image lasted seven minutes, eleven seconds It at first appeared contrary to Emmert's law, increasing in size when the screen was brought closer, decreasing when the screen was moved away, but a few minutes later it conformed to Emmert's law

Her imagery seemed to be of the "physiological" type in that she appeared to have no control over the duration of the image Though she plainly showed fatigue, when her images lasted five minutes or longer, she patiently propped her chin upon her hands, eyed the screen steadily, and reported wearily at intervals, "It's still there." In contrast, subject 10 appeared to be of the "conceptual" type in that he impressed the experimenters as being able to banish his image at will He seemed to look at it as long as he found it interesting and then dismiss it Subjects 19 and 10 both manifest marked concentration and perseverance in their play activities. The little boy appears to be aware of his spontaneous imagery, and to play consciously with his images

Summary and Conclusions

The investigation reported is an experimental study of the visual eidetic imagery of a group of preschool children The purpose of the experiment was to determine whether the technique of testing for

eidetic imagery could be successfully adapted for use with preschool subjects. The investigation was undertaken as a preliminary study, with the intention of making more extended investigations if a satisfactory technique could be worked out. The investigators recognized the difficulty of making the test intelligible to young children, and the further difficulty of securing introspective reports from such young subjects However, the need for experimentation with preschool children was evident, since no organized study had previously been made of the eidetic imagery of a preschool group.

The present investigators experimented with 20 nursery school children, ranging in age from 24 to 64 months, with a median age of 43½ months. Two series of stimulus-pictures and -objects were shown to the subjects. The subjects were tested first for after-images and then for eidetic images. Fifty-five per cent of the children reported after-images during the first testing During the second testing, after the technique of fixating had been demonstrated, 85 per cent reported after-images. Two-thirds of the after-images were described as being in positive colors, with the remainder negative, achromatic, or in other colors. It is possible that many of the presumed after-images were really eidetic images, especially since, according to Jaensch, young children are more likely to be of the "unitary type" The average duration of the after-images was 66 seconds for the first test series and 71 seconds for the second

The technique used in testing for eidetic imagery consistently distinguished between eidetic and non-eidetic subjects, as the same ten children reported eidetic imagery in each of the two test series The correlations between duration of images and number of details enumerated were high: 95± 02 for the first series and .88±.04 for the second The correlation between the two parts of the test was 75±.09 when number of details was used as the criterion for ranking the eidetic subjects, but only 48± 16 when duration of images was used as the criterion.

The eidetic images were in almost all cases positive In the first series, the average duration of the images was 53 seconds, and the average number of details was 4.6, in the second series, the average duration was 56 seconds, and the average number of details was 4 8 Positive correlations were found between rank on the tests for eidetic imagery and both chronological age and mental age, the correlations with mental age were higher than those with chrono-

logical age The correlations with age were lower for the second test series than for the first series or for the total test, possibly because the stimuli in the second series appealed more strongly to the so-called "physiological component" of eidetic imagery

The records of the preschool subjects on the first test series were compared with those of a group of 45 first-grade children, averaging 80 months in age After-images were less frequently found among the preschool children (in the first test series, that is), but were of longer duration, 66 seconds as compared with 14 seconds. The after-images of the school children were predominantly negative, while two-thirds of the after-images reported by the preschool group were positive.

Eidetic images were more frequently found among the preschool subjects (50 per cent as compared with 42.2 per cent), and were, moreover, always experienced with open eyes by the preschool children, while two-thirds of the first-grade children who experienced eidetic images did so with eyes closed. The duration of the images was longer for the preschool group, averaging 53 seconds as compared with 26 seconds for the first-grade children. In both groups, the coloring was positive, except for a very few achromatic images. The average number of details was 4 6 for the preschool children and 4.1 for the first-grade children.

The results of this preliminary study seem to indicate that the technique of testing for eidetic imagery can be adapted to the understanding of preschool subjects and that the results of such testing are reliable In the small groups tested, eidetic imagery was found more frequently and in stronger degree among preschool than among school-age children. Further investigation with preschool subjects is needed The authors of the present experiment have already begun work upon several phases of more extensive and also more analytical investigation.

Problems for Further Investigation

The preliminary study has suggested a number of problems which the writers hope to investigate.

1 A more analytic study of preschool subjects known to be eidetic, using apparatus that permits automatic control of exposure-time and of distance, so that the operation of Emmert's law can be more carefully checked than was possible in the present investigation,

and so that such problems as the density of the image, the effect of different colors in the stimulus, and the reappearance of the image on successive days, can be studied more objectively

2 A statistical comparison of eidetic phenomena at the various preschool age levels, with an adequate number of subjects.

3. A comparison of the imagery of young children of various racial groups

4 A study of parent-child similarity in imagery.

5 A study of the relation of the alleged psychophysiological differences in eidetic types (T-type and B-type) to differences in body chemistry

6 Investigation of the theory that in very young children of the "unitary type" eidetic images, after images, and the perceptual processes are closely related.

7 A reexamination of the theories of color vision, in the light of evidence offered by the various investigations of the after-images and eidetic images of children

8. A study utilizing records, made with the eye-movement camera, of eye-movements during the examination of the stimulus and the projection of the image. There is no evidence at present that indicates to what extent eidetic imagery depends on the chemical reaction of the retina and to what extent it depends on eye movements.

9 An investigation of the relationship, among adolescents, between eidetic ability and literary appreciation as measured by standardized tests

10 Investigation of the various kinds of eidetic imagery other than the visual

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(Résumé)

L'investigation rapportée est une étude expérimentale des images visuelles eidétiques d'un groupe de vingt élèves d'une école maternelle (nursery school), âgés en moyenne de 43½ mois Le but a été de déterminer, avant les investigations possibles d'une nature plus étendue, si la technique de tester pour les images eidetiques pourrait être adaptée avec succès pour l'usage avec les sujets d'âge prescolaire Le besoin de l'expérimentation a été évident puisque l'on n'a fait aucune étude organisee de cette sorte auparavant

Dans chacune de deux séries de tableaux et d'objets de stimulus, il y a eu premièrement un test pour les images consécutives et ensuite pour les images eidétiques. Des images consécutives ont été rapportées par la plupart des sujets, ont été positives en deux tiers des cas, et ont duré 68 secondes en moyenne Des images eidétiques ont été rapportées par la moitié des enfants, ont été positives pour la plupart, ont duré 54 secondes en moyenne, et ont contenu 4,7 détails en moyenne On a trouvé des corrélations positives entre le rang des images eidétiques et les âges et chronologique et mental. Comparé à un groupe de 45 élèves de la première année de l'école élémentaire, le groupe préscolaire a montré les images eidétiques plus fréquemment et à un plus haut degré. Les résultats semblent indiquer que la technique de tester pour les images eidétiques peut être adaptée pour les sujets d'âge préscolaire et que les tests sont valides.

PECK ET WALLING

EINE VORUNTERSUCHUNG DER EIDETISCHEN ANLAGE BEI VORSCHULPFLICHTIGEN KINDERN

(Referat)

Diese Untersuchung ist ein experimentelles Studium der optischen Anschauungsbilder bei einer Gruppe von 20 Kinderstubenkindern im Durchschnittsalter von 43½ Monaten. Diese Untersuchung zielt darauf hin, die Bestimmung zur weiteren Untersuchung zu machen, ob sich diese Methode fur eidetische Anschauungsbilder zum Gebrauch bei vorschulpfichtigen Kindern anwenden lasst. Die Notwendigkeit solcher Versuche war augenfällig, da keine solche Untersuchung dieser Art vorher gemacht worden ist

In jeder von zwei Reihen von Reizbildern und Objekten wurde zunachst fur Nachbilder und dann fur Anschauungsbilder gepruft. Nachbilder wurden von der Mehrzahl der Vpn angegeben; diese waren positiv in zwei Drittel der Falle und dauerten im Durchschnitt 68 Sekunden. Eidetische Vorstellungen wurden von der Halfte der Kinder angegeben; diese waren meist positiv, dauerten im Durchschnitt 54 Sekunden und enthielten im Durchschnitt 4,7 Details Positive Korrelationen wurden zwischen dem eidetischen Rang und sowohl dem chronologischen wie geistigen Alter festgestellt Im Vergleich zu einer Gruppe von 45 Kindern der ersten Stufe (first grade) wies die vorschulpflichtige Gruppe Anschauungsbilder haufiger und zu einem starkeren Grade auf. Die Ergebnisse scheinen darauf hinzuweisen, dass die Methode zur Untersuchung der Eidetik auf vorschulpflichtige Kinder angewandt werden kann und dass die Tests zuverlassig sind

PECK UND WALLING

ON THE PROBLEM OF "ALL FOURS" LOCOMOTION*

David M. Levy and Simon H. Tulchin

In collecting material for his study of *Children Who Run On All Fours* (4) Hrdlicka has opened an interesting problem on this phase of human locomotion. His method consisted in gathering data through letters from parents. It is a "correspondence research" and naturally suffers from the type of data offered. Nevertheless, the wealth of instances of this type of behavior, often with photographs, has confirmed Hrdlicka in his conclusion that walking on all fours is "a weakened but apparently still a continued inheritance from the prehuman past" (p. 17).

There are a number of facts gathered by Hrdlicka that weaken his theory. There is, for example, a sex difference. "All fours walking" occurs more frequently in males, in the proportion of three to two, a point Hrdlicka explains on the basis of "greater muscular strength and activity of the male child." But the phenomenon occurs more frequently among first born, for which this explanation cannot hold. Hrdlicka makes the blanket assumption that it occurs more frequently among negroes (although he has received only a single record from an American negro). He believes their meager response was due chiefly to lack of education.

Our thesis is that the phenomenon of walking on all fours may be explained more rationally by factors other than "phylogenetic persistence," namely (1) spasticity of the legs, however mild, due to organic disturbance of the central nervous system, most frequently through birth trauma; (2) a transition stage between creeping and walking, when standing or the ability to stand occurs simultaneously or in close relation with creeping. This stage is related to the problem of maturation. Like the first condition, it would tend to keep the legs in extension during the creeping stage. (3) A third source, probably infrequent, is derived from regressive behavior in infants who, after a short period of walking, return to creeping, though with legs in partial extension, when an illness intervenes, or in response to psychic regression.

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That spasticity is a factor may be inferred theoretically from Hrdlicka's own material Take, for example, the sex difference. Of his 369 instances, the proportion of males to females is three to two This is in keeping with the greater probability of spasticity in male infants, as is well known In Sachs and Peterson's tabulation of 225 cases of infantile cerebral palsy, the proportion is also about three to two—134 males to 91 females (5). A significantly large number of first borns of both sexes are found This difference also Hrdlicka explains in terms of muscular and nervous vigor But the greater susceptibility to spastic palsy among first borns among primipara seems a more consistent explanation (2, 5, 6). Furthermore, his percentages of "all fours" decrease with the later born, as also in spastic palsy He mentions (p 87) "a curious coincidence" in children who walk on all fours as walking on tiptoes This, of course, may be related to spasticity He cites nine cases in which this occurs and in two instances the tendency continued while walking. The knee is described as stiff in nine instances, i e., the legs are kept in the extensor position Further evidence of the theory that spastic palsy may explain a number of his cases occurs on page 275, a history of birth injury; page 276, peculiar spells, page 304, retardation in sitting alone until nearly twelve months; page 306, evidence of mental deficiency. In the instances enumerated, the symptoms of delayed development, mental deficiency, birth injury, epileptic-like seizures, are points that favor the diagnosis of spastic palsy.

The relation of birth injury to minor problems of neuro-muscular coordination has naturally received less attention than the clear-cut pictures of infantile spastic palsy. Recent studies indicate that hemorrhage in the skull is a frequent result of the birth process, and that "in infants born dead or dying soon after birth, one of the commonest lesions is a hemorrhage over the convexity near the midline so situated as to compress the leg center" (2) Consequences in the form of gross lesions of the central nervous system are fortunately infrequent As compared with them, relatively minor effects revealed clinically in clumsiness, slight spasticity, and the like, yet without well-defined clinical features, may be a more frequent finding They may occur in children whose general picture of good health and strength corresponds to that of many of the children in Hrdlicka's group.

Any factor that favors extension of the legs has the following possible effects on the progress of locomotion By interfering with flexion at the knee it may (*a*) prevent the knee-hand crawl (creeping) and (*b*) help retain the earlier stage of "hitching," i e, propelling the body forward by hands or elbows (with either no assistance from the extended lower limbs or a pushing action of the feet against the floor), or other forms as rolling, twisting, buttock propulsion in sitting position forwards or backwards (*c*) It may cause the hand-foot crawl ("all fours" locomotion) or (*d*) the crawling (hitching) or creeping stage may be eliminated entirely so that standing and walking occur without these preliminary stages

It is not argued that all the variations enumerated are due to spasticity, merely that if spasticity of the legs is present, it must necessarily favor them An example of a frequent type of neurologic picture in which spastic palsy may be diagnosed only by inference is best taken from the group of mentally retarded. We are selecting one of these in which the parents had moving pictures of the child when it walked and ran on all fours. The patient, a girl and an only child, was examined at 22 and at 28 months of age. In both studies, according to the developmental scale of Gesell, she was retarded about 12 months When first seen, locomotion was in the form of walking, "all fours" creeping and buttock crawling (propelling buttocks forward in sitting position, using the hands to aid in lifting the body and the feet, as a forward brace) and walking occasionally on her toes (The period of all fours locomotion occurred at about 13 months of age and is still occasionally present.) The findings favoring an inference of spastic palsy are the following: (1) the infantile extensor reflexes of the big toes are still present, (2) occasional athetotic movements of the fingers, (3) slight ataxia, (4) walking on toes, and (5) (*a*) history of a "torpor" during the first six months of life, (*b*) developmental delay, (*c*) a difficult labor in a primipara age 31, though without forceps.

The patient described may give the impression of a very obvious case of organic disease Nevertheless, she presented no gross evidence of spastic palsy The neurological evidence in the case was limited enough, though clear In the case to follow, that of an apparently healthy, strong and bright boy of 8 years, the evidence is still more of an inferential quality Nevertheless, his period of "all fours" locomotion seems logically related to some disorder, however mild,

of the central nervous system The patient was referred because of his difficulty in learning to read. He was the second of two children, born with the aid of low forceps after a severe labor He was a very active, restless baby, and slow in his development First tooth appeared at one year, at which time he started to creep on hands and feet. The mother states. "His legs would be stiff and not bent at the knees" He stood in his crib at 10 months of age, two months before the "all fours" walking "At 16 months when he started to walk he ran across the room" Physical examination revealed slight external strabismus of the left eye, inequality of knee jerks, a crossed Babinski, slight incoordination, jerkiness of fingers, and general clumsiness in handling fine objects

The cases cited might be duplicated many times They point to the possibility of an organic explanation for a number of Hrdlicka's cases. Further data may be gathered on the early problems of locomotion in children with well defined spastic palsies, but the examples cited at least indicate a strong probability that the "all fours" phenomenon may be due to organic factors that favor extension of the lower limbs

A second source of the "all fours" locomotion is derived theoretically from differences in the rate of maturation Such differences are in turn related to functional facilities in locomotion. An infant, for example, may stand up in his crib before he is allowed to have access to the floor If such an infant is given free opportunities to move about on the floor after standing with support has been accomplished, we would expect variations on that account in the creeping and crawling patterns The greater the infant's facility in standing, the more likely, under the circumstances described, would extension at the knee tend to appear in the creeping pattern. This may be stated also in terms of the age of the infant The older the infant when it begins to stand, the more likely (if creeping follows) will it tend to keep the legs in extension (i.e, "in readiness for walking.") This statement is based on observations that maturation *per se* is of special importance in locomotor progress (3) Our own findings indicate that the older the infant at the onset of standing, the sooner is it likely to walk, regardless of other considerations The second case cited is in point. Besides spasticity, the problem of maturation complicates the picture since the boy stood up at 10 months, some time before he began to creep

The locomotor pattern typically progresses from crawling (propulsion with torso touching the floor), to creeping (propulsion with raised torso), to standing, to walking (1). In healthy children factors interfering with the usual progress of these patterns have to do with parental interference with crawling, hampering clothing (especially the long baby dresses of the past generation), prolonged confinement to the crib, and obesity. Indeed, (unlike Hrdlicka) we would infer that in primitive or other groups in which locomotor activity is free, the typical progression would be found more frequently than in the urban population.

Data on the age of onset of locomotor patterns, based on the mother's memory for events years past, suffer naturally in accuracy. Some years ago we utilized the facilities of Better Baby Shows in the county fairs of Illinois for several studies, among them the collection of observations and records of the walking stages. We had the advantage, through physical examinations, of selecting presumably healthy children, of inquiring about onset only for the infants under observation and of checking the mother's memory through comparison with a group of children in whom the onset of the pattern occurred within a month of our own observation of it.

In the two tables following, dates of onset are given by age in months for standing and walking. The second table contains a selection of data from the first, in which the pattern of locomotion described began within a month of the day of observation. It is a check on the reliability of data in Table 1.

The next table that follows designates intervals in months between certain earlier stages of locomotion and the final stage of walking. It was tabulated from a rather small number of cases in which accurate data both on the early patterns of locomotion and the date of onset of walking without support were available. It shows that the "all fours" creeping is closer to walking than the other forms. Since we know that the interval between standing (with support) and walking (without support) is just about three months, the progression of patterns goes in the order: crawling, hand-knee creeping, hand-foot creeping (all fours), standing.

That maturation per se is a factor determining the length of time intervening between progressive patterns of locomotion may be demonstrated in Table 4. It shows generally that the older the

TABLE 4

TIME INTERVAL BETWEEN WALKING WITH AND WITHOUT SUPPORT IN RELATION TO ONSET OF WALKING WITH SUPPORT

Onset in months Walking with support	Intervals < 1	1	2	3	4	5	6	7	Total No of cases	Md.
6				1	1				2	3 5
7		1	3	4	4				12	3 5
8	1	7	6	10	4	2			30	3 1
9	1	8	17	11	4	2			43	2 8
10	2	13	17	7	2	2		1	44	2 4
11	3	12	19	5	4	1			44	2 4
12		14	6	6	3	2	1		32	2 3
13		4	2	1					7	1 8
14	1	5	1						7	1 5
15		1							1	
16			1						1	
17										
18			1						1	
Total No of cases	8	65	73	45	22	9	1	1	224	

infant when it begins to walk with support the sooner will it reach the stage of walking without support

The "all fours" pattern occurs much more frequently than is generally supposed In the study of crawling and creeping actually observed in the Better Baby shows, and in which detailed notes were available, we found it eleven times, and in a modified form (two hands—foot-knee creeping) three times; i e., *fourteen instances in 83 infants.*[1] This frequency is not surprising The "all fours" pattern, when it appears, is part of an orderly process in locomotor progression, between the creeping and standing stage. Evidence of the frequency of the "all fours" pattern completes the data relating *to the second point of our thesis, namely, that the pattern is a* transition stage between creeping and walking, and is brought out in healthy children through the process of maturation, so timed that the ability to stand and the creeping stage are closely related in time The fact that the phenomenon is not infrequent also favors the view that it is a natural variation under the conditions stated of the knee-hand creeping pattern.

For the third source of "all fours" locomotion we have no examples available Regression to this stage after walking has been accomplished, whether through an intervening illness or through a return on a psychological basis to earlier infantile behavior, is included at the present time as a theoretical possibility.

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[1]The patterns follow· creeping hand-knee, 40, hands-knee-foot, 3, hands-feet, 11. Crawling "scooting," 19, propulsion in sitting posture, 3, rolling, 4, other forms, 3

SUR LE PROBLÈME DE LA LOCOMOTION "À QUATRE PIEDS"

(Résumé)

On a fait une étude du phénomène de la locomotion à quatre pieds chez les petits enfants Elle a été stimulée par la conclusion du Docteur Hrdlicka d'une recherche dérivée principalement de la collection de données au moyen de lettres de correspondants ordinaires que cette forme particulière de locomotion est "un héritage faible mais évidemment encore continu du passé pré-humain" Dans l'étude faite, on a classifié les observations des formes locomotrices chez des centaines d'enfants normaux, on a cité des études cliniques de la paralysie cérébrale spastique qui montrent que la locomotion à quatre pieds sont un symptôme de l'état spasmodique, et l'on a utilisé de la statistique qui indique qu'elle est beaucoup plus fréquente que l'on ne croit ordinairement On explique le phénomène par autres facteurs que "la persistence phylogénétique," à savoir, sur la base de tous les facteurs dans la santé ou dans la maladie qui favorisent l'extension ou empêchent la flexion des jambes pendant la période de ramper On a trouvé ces facteurs dans (1) tous les dérangements organiques qui causent un état spasmodique des jambes, si léger qu'il soit, surtout ceux dûs au trauma de naissance, (2) une période normale de maturation où, principalement à cause des facteurs du milieu, la capacité de se tenir debout s'est montrée en même temps ou dans une étroite relation avec l'action de ramper, (3) le comportement régressif chez les enfants qui rampent de nouveau après une courte période de marcher, bien que les jambes soient partiellement étendues, à cause d'une maladie intermédiare ou en reponse à la régression psychique.

LEVY ET TULCHIN

DAS PROBLEM DES GEHENS AUF ALLEN VIEREN

(Referat)

Eine Untersuchung des Phanomens des Gehens auf allen vieren bei kleinen Kindern wurde vorgenommen. Dies wurde durch Dr Hrdlickas Schluss aus einer Forschung angeregt, der hauptsachlich durch die Sammlung von Daten vermittelst Briefe von Laienkorrespondenten gewonnen wurde, und der besagt, dass die besondere Form der Bewegung durch eine "entkraftigte, aber scheinbar noch eine fortdaurende Vererbung aus der vormenschlichen Vergangenheit" sei. In dieser Untersuchung wurden Beobachtungen der Bewegungsmuster bei Hunderten von normalen kleinen Kindern gemacht und aufgeschrieben Falle von Gehirnkrampflahmung wurden angegeben, welche das Kriechen auf allen vieren als ein Symptom der Spastizitat darwies Die statistische Behandlung der Ergebnisse ergab, dass das Gehen auf allen vieren haufiger sei, als allgemein angenommen wird. Das Phanomen wurde durch andere Faktoren als die "phylogenetische" Beharrlichkeit erklart, namlich auf Grund aller Faktoren bei Gesundheit oder Krankheit, welche die Ausstreckung der Beine begunstigen oder die Biegung der Beine wahrend des Kreichenstadiums verhindern. Diese Faktoren fanden sich bei allen organischen Storungen, welche (1) Spastizitat der Beine verursachen, ganz egal wie mild, besonders bei denen, die durch Geburtswunden entstanden sind, (2) ein normales Reifungsstadium, in dem die Fahigkeit zum Stehen hauptsach-

lich durch Umweltfaktoren gleichzeitig oder in enger Beziehung mit dem Kriechen stattfand, (3) regressives Verhalten bei kleinen Kindern, die nach einer kurzen Zeit des Gehens das Kriechen wieder aufnehmen, obgleich sie die Beine teilweise ausgestreckt halten, was durch eine dazwischenkommende Krankheit oder durch eine geistige Ruckkehr verursacht wurde.

LEVY UND TULCHIN

SIDEDNESS AS AN ETIOLOGICAL FACTOR IN STUTTERING*

From the Speech Clinic of the University of Minnesota

BRYNG BRYNGELSON

Speech pathology, which in recent years has come to be considered very closely related to the medical sciences, is that science which deals with disorders of speech in an attempt to understand them through etiology, nature, symptomatology, and treatment

The problem of stuttering, its etiology and treatment, has attracted the attention of psychoanalysts, otolaryngologists, pediatricians, and speech pathologists for many years. In the early history of man, stutterers were thought to be possessed of devils or other evil spirits. As late as 1841 surgery was the method employed in a cure. The surgery was then directed mainly to the tongue Adenoids and tonsils received their share of attention Peppermint oil and smoking were recommended for the allaying of the spasms of the speech musculatures.

During the past 15 years, stuttering has been subjected to rather careful laboratory, experimental, and clinical study The experimental approach has been largely sponsored by Dr. Lee Travis of the State University of Iowa His work on action currents has attracted nation-wide attention. At the University of Minnesota we have studied the problem from the clinical angle, and have been able to throw considerable light on stuttering through intensive research on sidedness and handedness We are now engaged in the study of stuttering from the standpoint of heredity

As a result of extensive research in the Iowa laboratories, Travis (9) has come to believe that stuttering is a temporary, recurrent reduction in dynastic control of superjacent levels over their substructures, causing a general disequilibrium of orientation potentials within the nervous system The stutterer lacks, according to the theory of cerebral dominance, a dominant gradient of excitation of sufficient potency and complexity to integrate the bilateral structures

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used for speech. *This dominant gradient in normal speakers is believed* to be resident, at the time of the execution of the speech, in one cerebral hemisphere. Lacking this higher type of nervous integration, as the stutterer appears to do, it is difficult and often impossible for him to speak in a normal, smooth flowing rhythm.

Because handedness has been considered a major sign of brainedness (left or right), there appears to be a good deal of confusion in the literature as to the relationship between handedness and stuttering.

This paper attempts to clarify the problem, and by indicating the data found on 700 clinical stuttering patients, we hope to arouse an interest among medical men in the problem of stuttering from a point of view which seems to offer a fertile field for investigation

Before presenting the charts which indicate a relationship between left-handedness and stuttering, we should like partially to clarify the existing confusion in the matter of handedness

Supporting one point of view are those who say that handedness is purely a matter of training, and who contend that it makes neither a *psychological nor a neurological difference in a child to make him* either a right-handed or a left-handed individual

Opposed to this belief are those who say that under no circumstances should the native handedness of a child be disturbed. They say that it is as natural to be left-handed as it is to be tall, fat, or blue-eyed, and that to change such a deeply-ingrained characteristic is a serious matter. In doing this, they say, one alters basic neurophysiological processes inherent in the nervous system.

The conflict of opinion, we believe, is due to different ways of *looking at the problem The study of the problem* has been approached with widely differing techniques and, in many instances, searchers in this field have not even been talking about the same thing

Yet *it is true that the practical significance* of the problem must still be considered All of us are aware of the fact that there are both right-handed and left-handed people. We have observed that the former are in the decided majority It is interesting to note, however, that at birth the right-handed majority is much less than we formerly believed it to be. *In a recent survey of four thousand* students in a university population (2), we find that when one includes the shifted individuals, the present left-handers and the am-

bidextrous, the percentage of native left-handers rises to 25 Former studies report that left-handed people constitute from four to six per cent of the population. This would probably hold true if one desired to know only the number who have remained left-handed from birth.

The left-handed problem has been a serious one for parents who have thought of it in terms of educational methods, particularly those concerned with writing and drawing Knowing that many teachers firmly believe that their first task is to shift a left-handed child, parents who share in this belief often perform this task for the teacher. They speak of the process as one of "breaking" the child The reasons most frequently given for this "shifting" procedure are rather superficial. A common reason given is that to be left-handed is a sin, and that a left-handed person is always viewed with distrust and suspicion. Others think that left-handed awkwardness in a right-handed world is inexcusable, and still others think that it is rude for a left-handed neighbor to poke one in the ribs at a dinner table. And certainly, some say, a cultured individual will never deal cards with the left hand. The most sensible reason I have yet heard is that given by a primary grade teacher when she was asked, "Why did you shift John to the right?" The reply was, "I did not know how to teach him left-handed writing."

Handedness, in and of itself, is not of fundamental importance It is merely a sign of a deeper nervous arrangement and, like many signs, has led numerous workers astray In other words, the hand does not always indicate the true situation. Our most important concern is that of sidedness By sidedness we mean that one side functions spontaneously in preference to the other in unpremeditated acts, and that it does so with greater facility and precision We think of the hand as one of the many symptoms of this sidedness There is also a native neurological choice in the foot which one uses in kicking, and when only one eye can be focused upon an object, we unconsciously choose the natively preferred eye There are many other signs of native sidedness, but these three are the most important It is also interesting to note that these signs do not always agree One can be right-handed and left-eyed, right-eyed and left-footed. In most of us, however, there is a great consistency indicating a definite sidedness. Travis (9) says, "One-sidedness is largely a matter of growth, of differentiation, attendant upon an

inherent process, which in turn is dependent upon stimulation of the sense organs by patterns of stimuli" Thus we see that, like nearly all human characteristics, sidedness is both inherited and acquired

We are of the opinion that workers have previously attached too much importance to the symptoms of sidedness and too little importance to what may lie beyond those symptoms. Following is a concrete example of this previously asserted fact, namely, that the signs do not indicate the true situation. A boy eighteen years of age had a hemorrhage of the right brain and subsequent paralysis on the left side. It seemed queer to some of us that he did not suffer any disturbance in his speech, because we thought that he had been left-handed The facts were that he did write with his left hand, but that he had learned to do so when he broke his right arm at the age of six Upon recovery, he went back to the right hand for all motor acts except writing. In other words, he was really right-sided from the standpoint of heredity, but he had been classed as a left-hander because he wrote with his left hand In this case the establishing of the writing function did not seem to make any significant change in his native dominance for speech, which was located in the left cerebral hemisphere Had the lesion occurred in the left brain, we could reasonably have expected a speech disturbance, as he was essentially a left-brained individual

Furthermore, sidedness represents unilaterality of nervous organization. The organization on one side of the nervous system, according to Travis' researches (8), is dominant over that of the other. Sidedness, then, is a sign of this unilateral organization, and eyedness, footedness, and handedness are, in turn, signs of this one-sidedness.

Thus we see that these common signs of sidedness which we talk about are quite removed from the real situation. This fact, we believe, accounts for the many conflicting opinions and findings on the relationship of so-called handedness and various types of disabilities.

Fortunately, the majority of people appear to have a deep-seated constitutional bias for a dominant motor lead in all acts of any complexity. This bias for unilaterality, we feel, is caused by developmental factors of heredity This is not the place to discuss the inheritance of left-sidedness, but we may say that the studies which have been made at the University of Minnesota seem to indicate that

left-handedness *is a sex-limited characteristic* (3) *It is most often* transmitted from the male through the female and back to the male When it occurs in a right-handed stock, *it* can *probably be considered* a recessive characteristic. It is interesting to note that there are 50 per cent more left-handers among the males than there are among the females (4)

There is no doubt that appropriate training can assist or hinder a natural bias which has already embedded itself in the nervous system. The shifting of handedness is still a common practice among parents and teachers This process, it is believed by many, may alter the general asymmetry which is responsible for the dominance of the right cerebral hemisphere Or, in the case of a partial shift to the right, one may have vascular symmetry, which can furnish a *physical basis for a lack of dominance in either one of the cerebral* hemispheres

We must not forget that the term left-handedness includes all degrees from a condition of inveterate left-handedness through an approximately equal degree of both right- and left-handedness, which training can effect in either direction, to a degree of right-handedness which is completely refractory to alteration by training

A lack of definite one-sidedness is a very serious condition For *many decades it has been common knowledge that writing, reading,* and speaking have unilateral lead representation. Any factor, then, which operates against the establishment of one-sided dominance, tends to interfere with normal establishment and development of those functions. In a sense, one cannot blame the teacher for what is *often a criminal treatment of children in this matter of shifting,* because many leading psychologists and educators, and, I dare say, some speech pathologists, are still telling people that there can be no possible harm in interfering with the native sidedness of either young children or adults Unquestionably, a few individuals effect a shift without any observable sign of disorientation, but we feel that in the majority of cases there is some resultant irregularity of nervous function

Just what do we believe takes place in a shift? The studies of Child (5), Coghill (6), Herrick (7), and others have indicated the fact that maturation and growth is the basic factor of behavior We think of growth as being largely a process of differentiation, and of one-sidedness as a good criterion of this growth process If this

growth process is retarded by working against the natural development of the child, we believe that he is either markedly delayed in becoming, or that he never becomes, one-sided, with the result that those functions which are known to be strictly dependent upon a one-sided nervous organization are either delayed in developing, or may never develop, in a normal way In other words, we feel that the best guarantee for normal reading, writing, and speaking is one-sidedness, and that tampering with a child's natural neurological expression is a dangerous procedure We recommend to parents and teachers that they give every child complete freedom to express spontaneously a preference for one side in motor activities Dr Ward once said, "He who attempts to make nature deviate from her normal physiologic processes may accomplish his immediate object, but it is very apt to be an exorbitant price"

When facts are at the basis of one's beliefs, one maintains that belief until new facts warrant a change. Fifty years from now other facts will undoubtedly force us to modify our opinions regarding the relationship between handedness and various disabilities But for the present, we are satisfied that this problem is of sufficient importance to warrant continued research We are still openminded as to the possibility that stuttering is an inherited mechanism, but until our current research is completed, we are inclined to maintain the present point of view The findings on 700 clinic cases of stuttering are here presented We are now engaged in a similar study of several hundred children who do not stutter, in an attempt to learn the percentage of shifts in the individuals, the percentage of left-handed histories, and the percentage of stuttering in the families If these percentages run as high as the ones here presented, obviously our interpretations will have to be altered We shall also know more about this important problem after a few generations have practiced a *laissez-faire* policy in regard to shifting There is the possibility that the reason we now find so few left-handed stutterers is that they have all been shifted to the right. There is now some indication that parents and teachers in the future are going to allow children freedom in the expression of side preference This, of course, is due to the fact that we have been able, particularly in the middle west, to build up quite a defense for the left-handed child, and are now able to teach the left-hander a good legible script in normal dextrad fashion, and to provide him with chairs, desks, scissors, pencil sharpeners, etc , suitable for left-handed manipulation

The data given in Tables 1 and 2 have been gathered by the interview and clinical methods In most instances, the parents of these cases have been questioned as to the facts about the patient, and as to his stuttering and left-handed relatives

Laterality Questionnaire

The following 20 items were used in determining the degree of handedness as expressed in a clinical situation. The questionnaires were scored according to the formula:

$$\text{Laterality Index} = \frac{R + E/2}{N}$$

R and *E* equal the number of items answered "Right" and "Either," respectively, and *N* equals the total number of items encircled An individual who encircled all the *R*'s would have an index of 1 00, while one who encircled all the *L*'s would have an index of 0 00 An index of 0 00 to 29 was considered left-handed, from 30 to .79 ambidextrous, and from 80 to 1 00 right-handed.

1	From which shoulder do you swing a baseball bat?	R	L	E
2	From which side do you swing a golf club?	R	L	E
3	Which hand drives a billiard cue?	R	L	E
4	Which hand swings a tennis racquet?	R	L	E
5	Which hand throws a ball?	R	L	E
6	With which foot do you kick a football?	R	L	E
7	Which hand uses a saw?	R	L	E
8	Which hand uses a hammer?	R	L	E
9	Which hand uses a can-opener?	R	L	E
10	Which hand uses a screw driver?	R	L	E
11	Which hand uses the scissors (shears)?	R	L	E
12	Which hand uses the tooth brush?	R	L	E
13	Which hand holds the knife in sharpening a pencil?	R	L	E
14	Which hand uses the needle in sewing?	R	L	E
15.	Which hand cuts with the knife when eating?	R	L	E
16.	Which hand spreads butter on bread?	R	L	E
17.	Which hand winds a watch?	R	L	E
18.	Which hand deals the cards?	R	L	E
19.	Which hand draws pictures?	R	L	E
20	Which hand do you use for writing?	R	L	E

The ages of the stutterers range from four to 42 years, and the majority were between nine and 16 years of age. In a number of instances, not all of the facts gathered here were obtained in one conference, for much of the data was secured from nurses, maids, grandmothers, and teachers who had had charge of the child in his early years This was often necessitated because frequently the parents, and often adult cases themselves, did not know the facts of early sidedness, and consequently one had to seek

TABLE 1
MALE STUTTERERS (463)

	(141) 16 yrs	(240) 9-16 yrs.	(82) 4-8 yrs
Stutterers in family*	70 67%	69 46%	77.46%
Left handed in family**	82 03	78 12	90 54
Shifted***	61 24	67 44	66 66
Handedness on entrance †			
Right	32 63	32 91	54 87
Left	2.12	83	0
Ambi	65 24	66 25	45.12
Eyedness ‡			
Right	31 00	28 24	3 65
Left.	66 66	62 96	90 24
Amphi	2 33	8 79	6.09
S. writing††			
Mirror	69 23	92 14	59 15
Neg	30 76	7.85	40 84
Age of onset ‡‡			
2-4 yrs	55 31	16 66	24.39
5-7 yrs	33 33	75 00	73 17
After 8 yrs	11.35	8 33	2 43
Disabilities of shifts §	(79)	(145)	(46)
Reading	59 49	34 48	19 56
Spelling	12 65	11 03	30 43
Writing	13 92	8 27	17 39
Articulation	0	10 34	0
Recommendations for therapy relative to sidedness in motor acts (Total of male stutterers, 463)			
Shifted to left—337		72 78%	
Shifted to right—2		43%	
Tie-up with right—121		26 16%	
Tie-up with left—3		62%	

*This refers to relatives of the patients studied These data include parents, grandparents, brothers, sisters, aunts, uncles, and cousins on both sides of the family. These high percentages may lead us to consider that stuttering is bred out of stuttering stock.

**This history refers to the relatives of the patients in the same way as that described for the history of stuttering in the family, going as far back into the relationships as the patient or his parents can recall

***This history revealed the fact that the patient, either as a child or at the beginning of his school life, had been influenced by parent, nurse, grandmother, maid, or teacher to develop motor skills with the (by nature) non-preferred side. Sometimes this attention was given the child from the beginning of his use of spoon in the high chair In other cases the shifting was introduced at the time of learning the writing skill in school In a few cases accidents to the naturally dominant side had shifted the hand and a portion of the speech function to the non-dominant cerebral hemisphere Again, others had been forced, through injury to the natural hand or arm, to shift their handedness In the great majority of cases the shifting refers to the interferences with the natural use of the left hand

information from relatives, baby pictures, etc. Sometimes it is not until the child is cured that the mother confesses to a shift in the child. Indeed, much prejudice has to be overcome before the truth is found, so it is seldom an easy task to secure the information concerning early sidedness history. We also feel that in the cases in which no positive information is revealed, there is a possibility that the native sidedness of the child could have been interfered with before he was old enough to have his handedness adequately observed. We refer to the relation of thumb-sucking to the dominant inherited

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†This has reference to the hand preference of the patient when he was first seen in the clinic. The high percentage of ambidexterity indicates that many of this pathological group were decidedly of a "mixed dominance" both in the peripheral and in the central mechanism. The criterion of handedness used was a laterality index computed from a questionnaire of twenty items involving unimanual activities.

‡When there is no injury to either eye, the majority of us have a natural choice for a sighting eye. In these cases the two tests used to determine the dominant eye were the Parsons' manuscope and the "hole in paper" test. The latter test is a simple one, but quite accurate. This patient is asked to hold an eight-by-ten paper with both hands and look through the hole in the center of the paper, at the observer's nose with both eyes open. The eye which the observer sees is the preferred sighting eye, provided there has been no injury to the other eye. Ten trials at varying distances are taken. If there are five right leads and five left leads, the patient is considered amphiocular, (amphi-) meaning that there is no established eye dominance.

††The patient is asked to take a piece of chalk in both hands and assume a writing position at the board. The examiner says, "I am going to give you a letter or a figure and I want you to write it with both hands at the same time. Write it immediately upon hearing the letter or figure and do not think about it. Keep your eyes closed during this test."

There are four possibilities in the direction of both hands in this test.

1	———→	———→	sinistro-dextrad, dextro-dextrad.
2	←———	———→	sinistro-sinistrad, dextro-dextrad
3.	———→	←———	sinistro-dextrad, dextro-sinistrad
4	←———	←———	sinistro-sinistrad, dextro-sinistrad

Number one is the most common response in normal right-handed speakers. Two, three, and four are recorded as mirrored writing with one or both hands. "Mirror," in Figures 1, 2, 3 means that either 2, 3, or 4 was the response in these cases. "Neg." refers to the fact that no mirror writing was recorded.

‡‡This refers to the year when the stuttering was first noticed by the parents or teachers. It is interesting to note that 55 per cent of the cases in the 16 years-and-over male group began stuttering practically with their first utterance, and 73 per cent of the 16 years-and-over female group began stuttering before the age of four.

§In addition to the stuttering, the cases whose history indicated a shift of handedness also had disabilities in either reading, spelling, writing, or articulation.

sidedness pattern In the out-patient speech clinic of the University Hospital, we have seen many cases in which the etiology of stuttering speech from the beginning lay in the fact of retarding native sidedness and subsequent speech development by tying the thumb-sucking hand One mother confessed to the act of keeping her child's left arm cuffed for six months for fear it would be left-handed if allowed to use both. Many mothers fear this because they do not know that the majority of children are ambidextrous until about the eleventh month.

In closing, we should like to call your particular attention to a few data which seem interesting in that the stutterers tend to fall into left-handed groups. Former studies have pointed out that stutterers are not as often like right-handed persons in many types of behavior as they are like the left-handed individuals.

TABLE 2
FEMALE STUTTERERS (237)

	(89) 16 yrs	(87) 9-16 yrs	(61) 4-8 yrs
Stutterers in family	90 90%	68 75%	86 04%
Left handed in family	89 15	81 57	82 75
Shifted	95.00	83 33	84 49
Handedness on entrance.			
Right.	77 52	17 24	19 67
Left	1.12	0	0
Ambi.	21 35	82 75	80 32
Eyedness			
Right	11 23	69 04	68 85
Left	77 52	7 14	13 11
Amphi	11 24	23 80	18 03
S writing			
Mirror'	78 65	83 58	90 19
Neg	21 34	16 41	9 80
Age of onset			
2-4 yrs	73 70	45 97	65 57
5-7 yrs	15 73	40 22	24 59
After 8 yrs	10 56	13 79	9 83
Disabilities of shifts			
	(76)	(65)	(49)
Reading	2 63	20 00	26 53
Spelling	1 31	0	26 53
Writing	1 31	4 61	0
Articulation	1 31	6 15	18 36
Recommendations for therapy relative to sidedness in motor acts (Total of female stutterers, 237)			
Shifted to left—182		76 79%	
Shifted to right—0			
Tie-up with right—55		23 20%	
Tie-up with left—0			

1. 57.34% of this group of 700 were left-eyed (Table 3). The normal right-handed people have been found to have 25% left-eyedness.
2. 10.28% were amphiocular (Table 3)—twice as many as in the normal population.
3. 61.14% were ambidextrous (Table 3). The normal population reveals only 5%.
4. 80.13% wrote mirror script (Table 3). The highest percentage found in our university population is 15%.
5. In the shifted cases, there is a rather high percentage of reading, spelling, writing, and articulatory disabilities, in addition to the stuttering which they manifested. In another study of 107 right-handed stutterers not quite ready for publication, we found *that 50% of them had reading, spelling, and writing disabilities*, while in 3000 right-handed normal cases with a negative history in stuttering, and left-handedness history in both the individuals and in the families, only 26% had difficulty in reading, spelling, or writing.

Finally, may we also state that it has not been the practice of those of us who are treating stuttering from the cerebral dominance point of view to shift[1] all stutterers to the left. This opinion has been expressed quite frequently in the literature, and the criticism is unjust. In the first 162 cases which were reported in the *Journal of Expression* for March, 1931 (9), we shifted only 55% and tied-up[2] 45% with the right side. The results in therapy were both very

[1]"Shifts" in the recommendations for therapy refer to those right-handed or ambidextrous stutterers who, on the basis of histories and diagnostic tests, were shifted to the left side of the body (peripheral) in all motor acts, and the right side of the central mechanism in all motor leads. This means that all right-handed activities were to be eliminated, and all ambidextrous acts, such as typewriting and piano playing, were advised against. Any ambidextrous activities tend to exercise both cerebral hemispheres in lead control, and this condition in itself only furthers the lack of dominance of one side of the brain.

When the diagnosis indicates a shift to the right, the same procedure is inferred for the right side.

[2]"Tie-ups" *refer to those patients to whom we did not recommend a shift* from their present handedness, but who were required to become more consistently right-sided, (or in some cases more left-sided), and to associate speech with writing. This means that the stutterer makes use of the margin of dominance which he already possesses, and attempts to increase that margin so that it will be of sufficient potency to integrate the mechanism for speech. If the stutterer had any left-handed activities, he was advised to eliminate them, and to stress entirely the leads from the right side of the body.

TABLE 3

SUMMARY OF 700 STUTTERERS

No of cases		Stuttering in family		L H in family shifted (R.L.)	
700 (463 m; 237 f)		443 or 74 57%		531 or 82 58%	460 or 73.13%
No information		106		57	71
No history		151 or 25 42%		112 or 17 41%	169 or 26 86%
Handedness on entrance			Eyedness		S writing
Right	266 or 38 00%	Right	214 or 32 37%	Mirror	480 or 80 13%
Left.	6 or 85%	Left.	379 or 57 34%	No reversal·	119 or 19 86%
Ambi	428 or 61 14%	Amphi	68 or 10 28%		
		No. inf 39	39	No inf	101
	Age of onset			Other disabilities	
2-4 yrs	284 or 40 57%	Reading	134 or 460 shifted cases, 29 13%		
5-7 yrs.	351 or 50 14%	Spelling	54 of 460 shifted cases, 11 73%		
8 yrs	65 or 9 28%	Writing	35 of 460 shifted cases, 7 60%		
		Articul ·	29 of 460 shifted cases, 6.30%		
Recommendations for therapy relative to sidedness in motor acts					
	Shifted to left	519	74 14%		
	Shifted to right	2	.28%		
	Tie-up with right	176	25 14%		
	Tie-up with left	3	42%		

satisfactory. In this group of 700 clinical cases (Table 3), the diagnosis indicated 74.14% or 519 cases as shifts to the left, .28% shift to the right, 25.14% or 176 cases tie-up with the right, .42% tie-up with the left. It is important to remember that the diagnosis in cerebral dominance is made primarily on the fact of *sidedness* and not on the fact of handedness. If you have followed the first part of this paper correctly, there should be no misunderstanding concerning the tables.

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LE CÔTÉ COMME FACTEUR ÉTIOLOGIQUE DANS LE BÉGAYEMENT

(Résumé)

On a étudié cliniquement à l'Université du Minnesota 463 bégayeurs et 237 bégayeuses.

La main et le côté sont deux facteurs différents quand ils se rapportent au processus de la parole. Un bégayeur droitier se montre ordinairement dans les tests cliniques de côté un individu gaucher dont l'usage de naissance de la main s'est altéré. Le côté est une organisation neurologique centrale qui dépend de la souche héréditaire. Le côté peut être le résultat de l'entraînement périphérique qui ne représente pas l'organisation neurale de naissance dans le cerveau.

Le bégayeurs viennent non seulement d'une souche bégayeuse en 75% des cas, mais la gaucherie dans la souche familiale de 700 bégayeurs a été

indiquée en 83% des cas 73% des 700 bégayeurs étudiés ont été originairement gauchers et de côté gauche Ils avaient été partiellement ou complètement changés par l'interposition du milieu

Les données semblent montrer le fait qu'un bégayeur possède une dominance neuro-physiologique mélangée. A cause de l'égalité du développement des deux hémisphères du cerveau, ni l'hémisphère droit ni le gauche ne peuvent inhiber les niveaux inférieurs de l'activité neurale de se charger des structures du milieu, innervées bilatéralement, mises en paires, employées dans la parole En plusieurs cas, la fonction appelée begayement ou *balbutiement peut être le resultat d'un déséquilibre neurologique causé par* l'interposition périphérique avec l'usage de la main L'usage de naissance du côté, croit-on, devrait être une considération importante dans le diagnostic et la thérapie des bégayeurs

BRYNGELSON

SEITIGKEIT ALS EIN URSACHENFAKTOR BEIM STOTTERN

(Referat)

463 Stotterer und 237 Stotterinnen wurden in der Universitatsklinik von *Minnesota untersucht*

Handenvorherrschung und Seitigkeit sind zwei verschiedene Faktoren, wenn sie sich auf den Sprachprozess beziehen Ein rechthandiger Stotterer ist gewohnlich nach klinischen Seitigkeitsversuchen ein linkhandiges Individuum, dem die angeborenen Handengebilde verandert worden sind Seitigkeit ist eine zentral-neurologische Organisation, die von der Vererbung abhangt Handigkeit kann die Folge einer peripherischen Übung sein, die der angeborenen Nervenorganisation des Gehirns nicht entspricht.

Stotterer entstammen nicht nur Stottererfamilien in 75% der Falle, sondern Linkseitigkeit in den Familien von *700 Stotterern* wurde in 83% der Falle nachgewiesen 73% der 700 Stotterer waren ursprunglich linkhandig und linkseitig *Sie haben sich teils oder ganz durch Umwelteinmischung* geandert.

Die Daten scheinen darauf hinzuweisen, dass ein Stotterer eine gemischte nervenphysiologische Vorherrschung besitzt Wegen der Gleichheit der Entwicklung beider Hirnhemispharen ist weder die rechte noch die linke Hemisphare imstande, die niedrigeren Schichten der Nerventatigkeit davor zu hemmen, dass sie zur Vorherrschung uber die zweiseitig gepaarte Mittelliniennervenstrukturen erlange, die beim Sprechen gebraucht werden. Bei vielen Fallen kann die als Stottern oder Stammeln bekannte Funktion *die Folge einer Nervenungleichheit sein, die durch den peripherischen* Widerstreit mit der Handigkeit entsteht Angeborene Seitigkeit, wie allgemein angenommen wird, sollte von wichtigem Belang in der Diagnose und Therapie der Stotterer sein

BRYNGELSON

WHOLE AND PART LEARNING OF A VISUALLY PERCEIVED MAZE*

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A survey of the conditions governing the relative efficiency of whole and part learning leads McGeoch to the conclusion that "experimental data, at the present time, do not justify any generalization regarding the specific or mutual effect of these factors" (8) It would seem that the interrelationships between the various factors effective in whole and part learning should be made the subject of a comprehensive program of research.

In our opinion some progress in disentangling the factors in any psychological problem may be made through study of the relation of general theories of the learning process to the data already gathered Following this plan Cook has made certain deductions from McDougall's two-factor theory of learning regarding the conditions affecting the relative economy of massed and distributed practice (2). The present investigation is an initial experimental test of Cook's hypothesis of a differential action of "insight" and "fixing" on the relation between whole-part learning and complexity of problem, with massed practice.

The assumptions of Cook's theory, as far as they affect the present investigation, are that with simple mazes the chief factor in the change from incorrect to correct choices is a comprehension of the position of individual errors in the total maze pattern. With increasing complexity, however, deletion of errors by "insight" plays less and less part in the total learning If his conclusions are correct, the relative economy of whole and part methods in maze learning should be to some extent a function of the size of the maze pattern. It also follows that the most economical unit for maze learning should be that amount of material whose total pattern (for subjects of any given level of ability and training) can be most readily grasped in a single trial Breaking such a unit into smaller "parts,"

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as well as using parts of a size too great to admit easy comprehension as a whole, should condition a decline in the relative efficiency of part as compared with whole learning (2, pp 340-341).[1]

The apparatus used in our investigation was a maze of the Shepard type, adapted for human subjects who are not blindfolded This maze, which has been described elsewhere (Morrison and Cook, 9), has the following characteristics which proved of advantage in the present connection (1) The stops are concealed and the subject can see the general plan of the top of the maze, as well as his own movement patterns while tracing. This seemed likely to avoid waste in combining the parts after each had been learned separately. (2) The units are exactly alike—a necessary basis for comparing patterns of different length. (3) Any number of comparable patterns can be constructed The stylus used in tracing the maze was a ¼-in copper tube 9 ins long. The tube was bent at right angles 1½ ins from one end, while the other end was taped for gripping with the hand. To the shorter (1½-ins) projection was soldered a short steel rod 1/16 in. in diameter, ending in a coin-shaped metal tip ½ in. in diameter and 3/16 in. thick.

The investigation consisted in a comparison of the relative economy of whole and part learning for two complexities of material. The size of maze pattern was determined by the number of units of "true" path, a distance corresponding to one side of a block being taken as a unit. Thus the maze patterns learned in Experiment I (Figure 1) have 12 units of true path in each pattern The necessity for a choice of paths at the end on each "unit" made it advisable to take the number of units rather than the number of turns in the true path as our measure of size of pattern. Since there are two incorrect routes at the end of each unit, the number of culs-de-sac (24 in Maze I and Maze II) is always double the number of units of true path. It is of course not assumed that mazes are of equal difficulty because they have an equal number of units Analysis along the lines indicated by Hull (7) must be carried out before maze patterns can be equated for difficulty prior to actual test. It

[1]A corollary to Cook's assumptions would be that plotting difficulty of learning against size of maze pattern should give a curve with initial positive acceleration followed by negative acceleration, ending in very slight negative acceleration or a straight line There are indications in Scott and Henninger's results that the empirical data (12, Figures 1 to 4) follow the assumptions of Cook's theory.

will be noted that there are never more than two units of "straight ahead" distance in any part of the true path in the four mazes The object of this feature of the pattern is to avoid over-simplification of the 6-unit parts of the 12-unit mazes.

The distinction between the part and the whole methods in all three of our experiments was that in the whole method the total maze pattern was traced on each trial, while in the part method each "half" of the pattern was learned separately, after which the two parts were traced together as in the whole method. The criterion of learning was three errorless trials. There are certain obvious advantages for our purposes in dividing the total pattern into two parts rather than the customary four The two-part division (1) lessens the amount of work needed for investigation of the relation of complexity of material to the whole-part problem, and thus permits study of a wider range of material in the time available, (2) greatly simplifies the conditions and thereby aids isolation of the significant factors, and (3) combines the pure part and combination part methods. In fact, the two-part rather than the four-part division seems to us the logical approach to the problem of whole-part learning.

The maze patterns were drawn on graph paper and the maze prepared before each experiment by the senior author At the beginning of a sitting the maze was placed on a table with its upper surface waist-high to the subject as he sat on a chair. The longer sides of the rectangular maze were parallel to the plane of the subject's shoulders and the starting point of each pattern was directly in front of and on the side of the maze nearest the subject, as shown by the arrows in Figure 1 The distance between the subject and the maze was adjusted to his length of arm. To prevent a subject from attempting to keep his orientation between trials by holding his gaze fixed on the end of the correct path, a black cloth was hung by loops from a wooden rod supported by a frame placed at right angles to the subject's line of regard, and about half-way between the subject and the maze The curtain was pushed aside by sliding the loops along the rod before beginning each trial, and pulled back in position as soon as a trial was completed.

Two experimenters were present during each session One timed the duration of each trial and the interval between trials, starting one and stopping another stop-clock at each change from work to

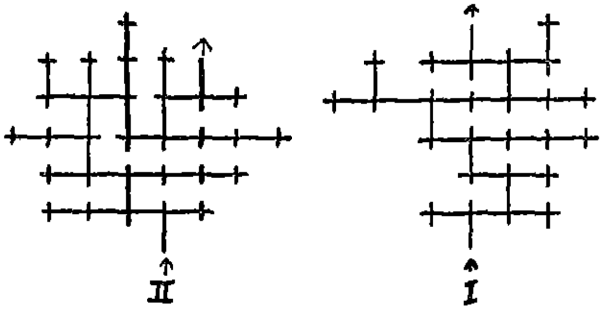

FIGURE 1

rest and rest to work. The other experimenter counted and recorded the errors, and replaced the stylus at the starting point during the interval between each trial. All subjects were students at Acadia University, chiefly sophomores and juniors from the prescribed course in elementary psychology.

EXPERIMENT I

Two maze patterns (Figure 1) consisting of 12 units of true path and with 24 blind alleys in each pattern comprised the subject's task in Experiment I Group *A* (6 women, 9 men) learned Maze I by the part method and Maze II by the whole method Group *B* (6 women, 9 men) learned Maze I by the whole method and Maze II by the part method Maze I was always learned first and Maze II second. The whole and part procedures were thus equated for group and maze differences and for amount of practice

At the beginning of the experiment the following typewritten instructions were presented to each subject.

> You are to trace two mazes The one will be learned as a whole, the other in two parts After both parts are learned you will trace that maze as a whole.

The instructions were repeated and emphasized verbally, and facility in the use of the stylus and curtain, as well as familiarity with the general nature of the maze problem, were gained by tracing a small practice maze Since the "end" of a maze pattern was in every case at least 5 blocks from any side of the total maze, and there were no visual cues to indicate where the pattern ended, the experimenter said "stop" as soon as the subject had finished tracing the correct path This path was defined for the experimenter by small

marks on the side of the blocks farthest from and thus not visible to the subject. Each subject learned Maze I and two minutes afterwards Maze II. Fifteen seconds elapsed between each trial and the next, but practice was "massed" in the sense that a maze was learned in a single sitting

The results appear in Table 1 and indicate a superiority of the part method over the whole method of 34 per cent in errors and 20 per cent in time The average number of trials is about the same in the two methods. The probable error of the difference

TABLE 1
TWELVE-UNIT MAZES EXPERIMENT I

	Errors	Time	Trials
Whole method	102 5	310.0 sec	19 2
Part method	76 5	255 0 sec.	19 8
Percentage of adv. of part over whole	34%	20%	—2%
Difference	26.0	55 0	— 6
P E $_{diff}$	7 67	24 0	

between the number of errors in the part and whole methods is 7.67 This difference is 3.4 times its probable error, which indicates 99 chances in 100 that the true difference is greater than zero The difference between the average time required for the part and whole method is 55 seconds, with a probable error of 24 The difference is 2.3 times its probable error, signifying 94 chances in 100 that the true difference is greater than zero.

EXPERIMENT II

The procedure in Experiment II was similar to that in Experiment I, except that the mazes (III and IV) were twice as large as Maze I and Maze II, i.e., composed of 24 units of true path and 48 culs-de-sac The 30 subjects who took part in the present experiment had no previous experience in maze learning Group *C* (6 women, 9 men) learned Maze III by the part method and Maze IV by the whole method Group *D* (6 women, 9 men) learned Maze III by the whole method and Maze IV by the part method. Maze III was always presented first and Maze IV second. On account of the increased difficulty of the larger patterns, the mazes were learned on successive days rather than during the same session as in Experiment I

TABLE 2
TWENTY-FOUR UNIT MAZES EXPERIMENT II

	Errors	Time	Trials
Whole method	431	1143 sec	38 4
Part method	347	*1120 sec*	43 *6*
Percentage of adv of part over whole	21	2	—14

Table 2, which gives the results for Experiment II, should be read as follows Groups *C* and *D* learned Mazes III and IV by the whole method with an average of 431 errors, 1143 seconds, and 38.4 trials, by the part method with an average of 347 errors, 1120 seconds, and 43.6 trials The differences between the part and whole methods are not statistically reliable, but the data have significance when taken in conjunction with the results of Experiment I and Experiment III

EXPERIMENT III

The only difference in procedure between Experiment II and Experiment III was that the subjects who assisted in the former were "unpracticed," while the subjects used in the latter (Experiment III) had previously acted as reagents in Experiment I. Since two of the women subjects serving in Experiment I were not available for the later work, each group in Experiment III was made up of 5 women and 9 men. Group *AB* (composed of individuals from Group *A* and Group *B*) learned Maze III by the part method and Maze IV by the whole method. Group *BA* learned Maze III by the whole method and Maze IV by the part method

TABLE 3
TWENTY-FOUR UNIT MAZES EXPERIMENT III

	Errors	Time	Trials
Whole method	368	1005 sec	34.3
Part method	257	816 sec	34.2
Percentage of adv. of part over whole	43	23	
Difference	113	189 sec	
PE_{diff}	33.24	85.2	

The results presented in Table 3 should be read as follows Groups *AB* and *BA* learned Mazes III and IV by the whole method

Part Methods in Trials, in Time, and in Errors In all three of our experiments the part method is markedly superior in number of errors and less superior in total time, while for trials the whole method is slightly more efficient in two of the three experiments. In attempting to find the significance of this trend we need only consider errors and trials, since in all three experiments the time records are intermediate between errors and trials in relative economy of the whole and part methods, and conditions differentiating between the other two measures bear in an intermediate fashion on time. One explanatory factor is inherent in the experimental method The three errorless trials required to satisfy the criterion of learning each part are included in our computation of total trials for the part method. However, this method of treating the data cannot be of crucial importance, since the subtraction of three trials from the total for the part method would in no case appreciably affect the relative economy of the whole and part methods in trials as compared with errors. A second condition seems of more significance. The difficulty encountered in putting the parts together bears much more heavily on trials than errors. With most subjects the experience gained in learning each part enabled subjects to combine the parts with few errors, even in the early trials. But these errors were disproportionately hard to eradicate About 61.4 per cent (68, 60, and 56 per cent in Experiment I, II, and III) of the total trials as contrasted with 28 to 29 per cent of the total errors were made in the act of combining the parts after they had been learned separately.

3 *Comparison of the Data from Experiments I, II, and III.* Considering errors alone (since the part and whole methods occupy the same relative position for errors, for time, and for trials in all three experiments), we find the advantage of the part method greatest in Experiment III, slightly less in Experiment I, and least in Experiment II. Analysis, which in view of the moderate size of the differences must be suggestive rather than final, indicates three factors that seem to merit further consideration.

a. Group differences (comparison of Experiments I and III with Experiment II). Experiment I and Experiment III, in which the same groups of subjects served first in the former and afterwards in the latter experiment, show respectively 34 and 43 per cent superiority for the part method by the error criterion A different

group of (inexperienced) subjects gave only 21 per cent greater efficiency for the part method in Experiment II Both groups were composed of college undergraduates of about the same degree of maturity and intelligence, and the number of subjects in each experiment (30) was large enough to secure fair reliability by the operation of chance, but it is impossible wholly to rule out the possibility of a group factor.

b Complexity of material (with amount of practice constant Comparison of Experiment II with Experiment I). The maze patterns traced in Experiment II were twice the size of those learned in Experiment I. The greater economy of the part method in the latter may be due to the simpler (12-unit maze) being a more favorable unit for part learning with unpracticed subjects

The relation of complexity of material to the relative efficiency of the part and whole methods in maze learning is two-fold.

1) *Relation of number of units in the maze pattern to difficulty of initial learning* There is some reason to believe that as amount of material is increased the corresponding increase in difficulty of learning is greater with maze learning than with verbal materials This point will be treated more fully in a later paper That the relation between amount of material and difficulty has played a part in the relative economy of the whole and part methods in investigations of maze learning is illustrated by the treatment of the data of Hanawalt, Pechstein, and the present experiments in Table 4 Description of the computation of the error values in Table 4 will show the method of obtaining the values for all measures[4] This method consisted in dividing the sum of the errors made in learning the (four or two) parts of a given maze into the number of errors made in learning the maze as a whole—that is, by the "whole" method[5]

In Table 4 a number larger than unity means that increase in size of maze pattern conditions a relatively greater increase in diffi-

[4]Trials are not included because, as Robinson and Heron have shown (11), the effort expended in learning material of different lengths is not adequately expressed by raw scores in number of trials In any detailed consideration of the relation of length of material to difficulty of learning, trials could be translated into "total units presented," but any such additional complications would be of no value here

[5]A somewhat similar method of computation is used by Scott and Henninger to obtain their "score per cul-de-sac" (12, pp 665-668, Tables II, III, and IV)

culty of learning. Although such widely divergent data show the need for experiment rather than theory, several tentative conclu-

TABLE 4

RATIO OF DIFFICULTY OF LEARNING PARTS TO DIFFICULTY OF LEARNING WHOLE MAZE

Each value is obtained by dividing the sum of a given measure (time, errors, etc.) for the two or four parts into the corresponding measure for the whole maze. *If difficulty increased in direct proportion to complexity all quotients would be unity. All numbers in the table are greater than unity, signifying that increase in size of a maze pattern conditions a greater increase in relative difficulty*

		Errors	Time		
Pechstein, 1917 (relatively simple maze learned in four parts)	Rats, distributed practice				
	Returns allowed	2.7	5.65		
	Returns prevented	1.4	2.25		
	Humans, distributed practice				
	Returns allowed	2.75	2		
	Returns prevented	1.75	1.7		
	Humans, massed practice				
	Returns allowed	8.7	6.55		
	Returns prevented	6.8	6.25		
Hanawalt (fairly complex maze, combination of massed and distributed practice. Four parts)		Errors	Time	Excess dist.	Total dist.
	Rats, 1931	1.3	2.2	1.25	2.0
	Humans, 1934	4.0	2.2	4.0	2.0
		Errors	Time		
Present experiments. (Maze in two parts)	Experiment I	1.8	1.8		
	Experiment II	1.85	1.7		
	Experiment III	2.2	2.1		

sions may be drawn. In the first place, the increase in difficulty is relatively much greater than the increase in complexity. All the numbers in the table are greater than one. Second, the increase in difficulty is relatively much greater with massed than with distributed practice. Pechstein's results are particularly striking, the ratios from 6.25 to 12.5 showing that an increase in size of maze pattern of four times causes an increase in difficulty of learning of 25 to 50 times. Our results indicate that doubling the number of units of maze pattern conditions about a fourfold increase in effort expended in learning, that is, the difficulty increases as the square of the size of the maze. Neither Pechstein's investigation nor our experiment, however, is wholly satisfactory, because of the wide divergence in effort expended in learning the earlier and later

parts of the total maze patterns. Pechstein found very great positive transfer from the first part to the other three sections of his maze, while in our work the reverse was true: the number of errors and total time, and to a less degree, the number of trials, were greater in learning Part II than in learning Part I.[6] Hanawalt's ratios might also be taken to indicate that the increase in difficulty with increase in size of pattern is not so marked for large amounts of material, but it is not possible to isolate the influence of this factor from that of distribution of time, since Hanawalt combined massed and distributed procedure in both whole and part methods In any case, it is evident that, if the waste in the act of connection can be reduced to or near zero, the relation of size of pattern to difficulty of learning will give the part method the advantage, especially with fairly simple mazes and massed practice

2) *Relation of complexity of maze pattern to difficulty of combining the parts* Pechstein concludes from his data that the major element of waste in part learning occurs in the act of connecting. There is no question of the correctness of this statement as far as maze learning is concerned. The fact that Crafts (3) and Davis and Meenes (4) have found greater economy in learning by the whole method with visual-spatial material, although it shows that the waste does not merely consist in the effort required in "forming an association" between two discrete parts (already learned), in no way negates Pechstein's conclusion. In fact it is not possible to explain *away* Pechstein's findings in this respect, since his generalization is no more than a plain statement of one of the results of all experiments in whole-part maze learning Our data indicate that the waste in the act of connecting is a constant factor for the two complexities of material tested In the part method, the percentage of the total errors which must be ascribed to the difficulty of connecting the parts is 28, 29, and 29 per cent for Experiments I, II, and III respectively That is, the effort expended in connecting the parts increases with increasing amount of material proportionately with the rise in the difficulty of learning the separate parts

[6]The fact that returns over the first part were allowed while learning the second part doubtless accounts for some of this difference Another possible factor is that the subject had a much better opportunity of maintaining orientation relative to his body while tracing the first half of a total maze pattern, since each "whole" maze pattern began at the row of blocks nearest his body.

c Practice (complexity of material constant) The unit of material for which errors can be most rapidly deleted may become larger as subjects get more and more practice in maze learning This process, rather than group differences, is advanced by the authors as the explanation of the greater economy of the part method in Experiment III as compared with Experiment II. The 24-unit mazes were learned in both of these experiments, but the subjects who worked in Experiment III had already learned Mazes I and II Since our hypotheses assume that increasing size of pattern and practice work in opposite ways, it follows that the two factors may partly or wholly cancel one another. On the latter supposition we can explain the smallness of the differences between the data of Experiment I and Experiment III The patterns for Experiment III were twice the size of the patterns for Experiment I. This factor operating alone might be expected to lower the relative superiority of the part method in the more complex mazes. On the other hand, the practice that subjects taking part in Experiment III had already received during their work in Experiment I might have increased their ability to handle the larger pattern at high efficiency, and thus have moved the "most economical unit" higher up in the scale of complexity of pattern.

Summary

For learning a visually perceived maze the part method was found markedly superior to the whole method in errors, less superior in time, while in number of trials there was little difference between the two methods The evidence, though inconclusive, indicates that practice, sight of the surface of the maze and the movements made in tracing, and relative simplicity of problem favor part learning.

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L'APPRENTISSAGE GLOBAL ET PARTIEL D'UN LABYRINTHE VISUELLEMENT PERÇU

(Résumé)

On a étudié l'economie relative des méthodes globale et partielle quand on apprend à tracer des formes dans un labyrinthe visuel adjustable Dans l'expérience I 30 sujets ont appris 24 formes de labyrinthe à cul-de-sac de 12 parties. Quarante-huit formes de cul-de-sac de 24 parties ont été apprises dans l'expérience II par 30 sujets sans exercice antérieur, et dans l'expérience III par 28 sujets employés antérieurement dans l'expérience I Dans toutes les expériences on a égalisé les effets de l'exercice et les différences entre les groupes et les labyrinthes Les résultats montrent que la méthode partielle est supérieure à la globale de 21 à 43 pour cent dans les erreurs moyennes et de 2 à 23 pour cent dans la duree moyenne. Dans les expériences I et III les proportions critiques ont été assez grandes pour être signifiantes statistiquement Pour les épreuves les deux méthodes ont été à peu près égales sauf dans l'expérience II, qui a montré un avantage de 14 pour cent pour la méthode globale. Le pourcentage peu élevé (28-29%) des erreurs totales pour la méthode partielle faites dans la combinaison des parties indique qu'un élément principal de perte avec la méthode partielle dans les expériences antérieures a été réduit au minimum en simplifiant l'acte de l'intégration des parties On attribue cette simplification à la division des formes totales en deux plutôt qu'en quatre parties, et à l'usage d'une labyrinthe visuel qui a permis aux sujets de voir leurs mouvements en traçant et ainsi de percevoir l'orientation générale des parties à la forme totale La petite quantité d'effort nécessaire pour combiner les parties a montré aussi plus clairement qu'auparavant un avantage intrinséque de la méthode globale l'augmentation disproportionnée de la difficulté de l'apprentissage avec la grandeur augmentante de la forme du labyrinthe Il s'est montré aussi quelque évidence que la méthode partielle est favorisée par l'exercice

COOK, MORRISON, ET STACEY

DAS GANZ- UND TEILLERNEN EINES VISUELL WAHRGENOMMEN LABYRINTHS

(Referat)

Die relative Ökonomie des Ganz- im Vergleich zum Teilverfahren wurde beim Lernen des Nachzeichnens der Muster in einem anordnungsfähigen, visuellen Labyrinth untersucht Im ersten Versuch lernten 30 Vpn Labyrinthmuster in 12 Einheiten und 24 Gangen Muster mit vierundzwanzig Einheiten und 24 Gangen wurden im zweiten Versuch von 30 "ungeubten" Vpn. gelernt, und im dritten Versuch von 28 Vpn, die fruher im ersten Versuch gedient hatten Übungswirkungen und Gruppen- und Labyrinthunterschiede wurden in allen Versuchen gleichgemacht Die Ergebnisse zeigen, dass die Teilmethode der Ganzmethode uberlegen ist, mit 21 zu 43 Prozent an durchschnittlichen Irrtumern und 2 zu 23 Prozent an durchschnittlicher Zeit. In Versuchen I und III waren die Verhaltnisse gross genug, *um statistisch bedeutsam zu sein* *Im Hinblick auf Proben waren* die zwei Methoden ungefahr gleich mit der Ausnahme von Versuch II fur die Ganzmethode, in dem ein 14-prozentiger Vorteil vorhanden war Der niedrige Prozentsatz (28-29%) der Gesamtirrtumer fur die Teilmethode bei der Zusammensetzung der Teile beweist, dass ein Hauptelement des Verlusts mit der Teilmethode in fruheren Experimenten durch die Vereinfachung des Aktes der Deutung der Teile vermindert worden sei Diese Vereinfachung wird der Einteilung der Gesamtmuster in zwei anstatt in vier Teile zugeschrieben, und dem Gebrauch eines visuellen Labyrinths, das den Vpn gestattete, ihre Bewegungen wahrend des Zeichnens zu beobachten und auf diese Weise die allgemeine Orientierung der Teile zum gesamtmuster wahrzunehmen. Die kleine Energieverwendung, um die Teile zu verbinden, zeigte klarer als fruher einen inneren Vorteil der Teilmethode die unverhaltnismassige Zunahme der Schwierigkeit des Lernens mit einer zunehmenden Grosse der Labyrinthmusters Es gab auch einige Evidenz, dass die Teilmethode durch Übung begunstigt wird

COOK, MORRISON UND STACEY

SHORT ARTICLES AND NOTES

HIGH SCHOOL ACHIEVEMENT OF FIFTY-SIX GIFTED CHILDREN[1]

EDNA E LAMSON

This study is part of a wider investigation (1) carried forward since 1922, when a group of children between the ages of seven and nine years were selected from public schools in New York City by means of Stanford Binet Tests for the purpose of founding two experimental classes of pupils testing above 135 IQ.[2]

The purpose of the present study is to answer certain questions regarding the *final* high school achievement of the children who were subjects in "A Study of Young Gifted Children in Senior High School" (2).

1. *Did all the members of the gifted group complete high school within* the time they had anticipated?

2. How do the gifted group graduates compare with the control graduates *with reference to ages and scholastic achievement?*

3. Was the scholastic expectation of the non-graduated group of 1929 fulfilled upon their graduation? (2, p 2)

4. Did the gifted group maintain its superior scholastic achievement throughout its high school career?

The data used in answering these questions consist of the following: Number of semesters spent in completing the high school curriculum; ages upon entering and upon completing high school; school marks and Regents record for the entire period spent in high school; membership in Arista League; and certain data from the 1929 study

The last two of the gifted group to be graduated from high school received their diplomas in June, 1931

The control group of graduates were selected by the method used in selecting the control group of survivors (2, p 5). The complete school record *was obtained for each of the graduates.*

The average number of semesters spent by the gifted group was 8 35 as compared with an average of 8 4 semesters spent by the control graduates. The difference is not significant

[1]*Detailed report of this follow-up study read before Sections I and Q,* American Association for the Advancement of Science, Atlantic City, December, *1932*

[2]This was done by the action of a joint committee, consisting of Mr Jacob Theobold and Miss Jane Monahan of Public School 165, Manhattan, and of Dr. Grace A Taylor, Miss Margaret V Cobb, and Professor Leta S Hollingworth of Teachers College, Columbia University, with the advice of District Superintendent John E Wade The work of this committee was financed in part by a grant from the Carnegie Corporation of New York.

Whereas the non-graduated group had hoped in 1929 to complete the remainder of their high school course within an average of 8.2 semesters (2, p 79), they spent 8 35 semesters The reasons for the increase in the aggregate time are known Five members of the gifted group entered a private high school which planned to require of them five years of attendance. One member discovered, upon moving from New York City, that the year's work he had done in private high school would not be credited upon the course he had decided to offer as preparation for college entrance During the four years he spent in the second high school, he completed five years of work, and upon graduation was granted one year of credit by the university he entered the following fall. His scholastic achievement was of sufficiently high order for him to be awarded a scholarship to the university.

One member of the gifted group finished the required number of college entrance subjects within the four-year period, but neglected to meet the graduation requirements in physical education During the ninth and tenth semesters this individual fulfilled the physical education requirements and took several academic subjects. Another member entered at midyear a private high school which regularly requires five years to complete its curriculum In this instance five and one-half years were required because the course is completed in June only. Two members who could have been graduated with the class of June, 1929, decided to take additional college preparatory subjects and voluntarily deferred their graduation for a semester

The data used in answering the question regarding the ages and scholastic achievement of the two groups are presented in Table 1 and Table 2

TABLE 1

COMPARISON OF GIFTED GROUP AND CONTROL GRADUATES WITH REFERENCE TO AGE AT CERTAIN STAGES OF THEIR HIGH SCHOOL CAREER

Ages	Gifted group	Control graduates	$\frac{\text{Diff}}{\text{P E Diff}}$
Average age in years upon entering high school	11 7 ± 055	13 5 ± .072	20.0
Average age in years upon graduation from high school	15 8 ± 061	17.6 ± .077	18.6
Age of youngest entrant	9 yrs 4 mos.	11 yrs 2 mos	
Age of oldest entrant	15 yrs 3 mos.	15 yrs 3 mos.	
Age of youngest graduate	13 yrs. 9 mos.	17 yrs. 7 mos.	
Age of oldest graduate	17 yrs 2 mos.	21 yrs. 5 mos	

On the average the gifted group was approximately two years younger than the control graduates at the time the respective groups entered high school and at the time the respective groups were graduated from high school. Throughout their high school period the gifted group was approximately two years younger than any of their control groups (2, p. 74), a *statistically significant fact.*

TABLE 2

COMPARISON BETWEEN GIFTED GROUP AND CONTROL GRADUATES WITH REFERENCE TO REGENTS EXAMINATIONS AND SCHOOL SUBJECTS

Sets of marks	Gifted group	Control graduates	Difference	Diff. / P E Diff.
Regents marks				
Mean	82.3	77.1	5.2	
S D of distribution	5.4	5.7		
Probable error				
Of mean	55	42	.67	
Of difference				7.7
School marks				
Mean	78.1	73.2	4.9	
S D of distribution	6.2	4.8		
Probable error				
Of mean	.56	34		
Of difference			66	7.4
Difference between the means	4.2	3.9		
P.E of difference	78	55		
Difference / P E. difference	5.4	7.3		

Both the final Regents record and the final record in school subjects made by the gifted group are significantly superior to that of their control graduates (2, pp 31-33). Both groups made a significantly higher record in *Regents Examinations than in school subjects Whereas 90 per cent of the* control graduates availed themselves of the opportunity to take Regents Examinations, every member of the gifted group having the opportunity to take Regents Examinations did so.

TABLE 3

COMPARISON BETWEEN 1929 SCHOOL MARKS OF 26 NON-GRADUATES AND THEIR 1931 SCHOOL MARKS WHEN THEY HAD BECOME GRADUATES

Sets of marks	1929	1931	Difference	Diff / P.E Diff
School marks				
Mean	76.7	76.8	.1	
P E of mean	1.31	1.21		
P E of difference			.36	.3

Whereas the non-graduated group had hoped in 1929 to complete the remainder *of their high school course within an average of 8.2 semesters* (2, p. 79), they spent 8 35 semesters The reasons for the increase in the aggregate time are known. Five members of the gifted group entered a private high school which planned to require of them five years of attendance One member discovered, upon moving from New York City, that the year's work he had done in private high school would not be credited upon the course he had decided to offer as preparation for college entrance During the four years he spent in the second high school, he completed five years of work, and upon graduation was granted one year of credit by the university he entered the following fall His scholastic achievement was of sufficiently high order for him to be awarded a scholarship to the university.

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Ages	Gifted group	Control graduates	Diff / P. E. Diff
Average age in years upon entering high school	11.7 ± 055	13.5 ± .072	20 0
Average age in years upon graduation from high school	15 8 ± .061	17.6 ± .077	18.6
Age of youngest entrant	9 yrs 4 mos	11 yrs. 2 mos.	
Age of oldest entrant	15 yrs 3 mos	15 yrs. 3 mos	
Age of youngest graduate	13 yrs 9 mos	17 yrs 7 mos	
Age of oldest graduate	17 yrs. 2 mos.	21 yrs 5 mos	

On the average the gifted group was approximately two years younger *than the control graduates at the time the respective groups entered high* school and at the time the respective groups were graduated from high school. Throughout their high school period the gifted group was approximately two years younger than any of their control groups (2, p. 74), a *statistically significant fact.*

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S.D. of distribution	5.4	5.7		
Probable error				
Of mean	.55	.42	.67	
Of difference				7.7
School marks				
Mean	78.1	73.2	4.9	
S.D. of distribution	6.2	4.8		
Probable error				
Of mean	.56	.34		
Of difference			.66	7.4
Difference between the means	4.2	3.9		
P E of difference	.78	.55		
$\frac{\text{Difference}}{\text{P E difference}}$	5.4	7.3		

Both the final Regents record and the final record in school subjects made by the gifted group are significantly superior to that of their control graduates (2, pp 31-33). Both groups made a significantly higher record in Regents Examinations than in school subjects Whereas 90 per cent of the control graduates availed themselves of the opportunity to take Regents Examinations, every member of the gifted group having the opportunity to take Regents Examinations did so

TABLE 3
COMPARISON BETWEEN 1929 SCHOOL MARKS OF 26 NON-GRADUATES AND THEIR 1931 SCHOOL MARKS WHEN THEY HAD BECOME GRADUATES

Sets of marks	*1929*	*1931*	Difference	$\frac{\text{Diff}}{\text{P E Diff.}}$
School marks				
Mean	76.7	76.8	.1	
P E of mean	1.31	1.21		
P E. of difference			.36	.3

In order to determine whether the non-graduated group of 1929 fulfilled their scholastic expectation upon graduation, the data in Tables 3-5 were assembled Table 3 presents a comparison between the 1929 school marks of the 26 non-graduates and their 1931 school marks when they had become graduates.

Table 4 presents a comparison between 1929 Regents marks and school marks for 16 non-graduates and their 1931 Regents marks and school marks when they had become graduates.

TABLE 4

COMPARISON OF 1929 REGENTS MARKS AND SCHOOL MARKS FOR 16 NON-GRADUATES AND THEIR 1931 REGENTS MARKS AND SCHOOL MARKS WHEN THEY HAD BECOME GRADUATES

Sets of marks	1929	1931	Difference	Diff / P E Diff
Regents marks				
Mean	83.8	81.6	2.2	
P E. of mean	1.01	1.01		
P E of difference			1.42	
				1.5
School marks				
Mean	81.0	76.3	4.7	
P E of mean	1.14	1.26		
P.E. of difference			1.69	
				2.8
Difference between means	2.8	5.2		
P E of difference	1.52	1.61		
Difference / P.E. difference	1.8	3.2		

Table 5 presents a comparison of the coefficients of correlation between Regents marks and school marks of 1929 and 1931 for 16 non-graduates of 1929

TABLE 5

COMPARISON OF COEFFICIENTS OF CORRELATION BETWEEN REGENTS MARKS AND SCHOOL MARKS OF 1929 AND 1931 FOR SIXTEEN NON-GRADUATES OF 1929

Set of marks	1929	1931	Difference	Diff. / P E Diff
Coefficient of correlation	86	.82	04	
Probable error of coefficient of correlation	.044	.055		
Probable error of difference			*07*	
				6

None of the differences in Tables 3-5 is statistically significant The 1929 scholastic expectation of the non-graduated group was fulfilled and the 1929 scholastic record of the entire gifted group was unaltered

To determine whether the gifted group has maintained its scholastic superiority, a comparison has been made in Table 6 between data from Table 7 of the 1929 study (2, p 32) and Table 2 of the present study

TABLE 6
COMPARISON OF THE SCHOLASTIC ACHIEVEMENT OF 1929 AND 1931 BY THE GIFTED GROUP AND BY THEIR RESPECTIVE CONTROL GROUPS

Sets of marks	Gifted group	Control graduates	Difference	P E Diff	$\frac{\text{Diff.}}{\text{P E Diff}}$
Regents marks, 1929	83 5	76 8	6 7	68	9 8
Regents marks, 1931	82 3	77 1	5 2	67	7 7
Difference	1 2	3			
P E of difference	53	48			
$\frac{\text{Difference}}{\text{P E difference}}$	2 2	.6			
School marks, 1929	78 1	72 9	5 2	6	8 6
School marks, 1931	78 1	73 2	4 9	.66	7 4
Difference	0 0	3			
P E of difference	.79	.56			
$\frac{\text{Difference}}{\text{P.E difference}}$	0 0	53			

The differences between the scholastic records of 1929 and 1931 for the gifted group and their respective control groups, both in Regents marks and in school marks, are small and not statistically significant. Although the differences between the averages made by the two groups both in Regents marks and school marks for 1931 are smaller than the corresponding differences for 1929, the average for the gifted group is still significantly superior The gifted group, true to prediction (2, p 42), has maintained throughout its high school career a scholastic achievement significantly superior to that of the control groups.

Of the gifted group attending high schools having Arista League 42.5 per cent were elected to this scholarship society From the control graduates 5 4 per cent were likewise elected The percentage of elections to Arista among the gifted group is approximately eight times as large as that among control graduates, and four times as large as the percentage for graduating classes in three high schools (2, pp 37-39).

The conclusions reached in the 1931 supplementary study are

1 The modal number of semesters spent by both the gifted group and the group of control graduates in completing the high school curriculum was eight The slight difference between the average number of semesters spent by the gifted group and by the control graduates is not statistically significant. Whereas, in 1929 the members of the gifted group expected to complete high school in an average of 8 2 semesters, an average of 8 35 semesters were needed

2 The final scholastic record of the gifted group, who were two years younger on the average than any of their control groups, was significantly superior to that of the control graduates.

3 The scholastic expectation of the 26 gifted non-graduates of 1929 was fulfilled when the entire group had been graduated The final record of the non-graduates of 1929 was the same as that of the graduates of 1929. The scholastic achievement between June, 1929 and June, 1931 on the part of the non-graduated group did not alter the 1929 scholastic record of the entire gifted group

4. The gifted group maintained throughout its high school career a scholastic achievement, including its disproportionate percentage of elections to Arista, significantly superior to that of the several control groups.

5. Young gifted children in senior high school tend to maintain superior intellectual achievement throughout the entire course

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BOOKS

NORMAN L. MUNN. *A Laboratory Manual in General Experimental Psychology.* Pittsburgh: Univ Pittsburgh Book Store, 1934 Pp. 114+ supplementary question pages, lettered *a*

In considering a Psychology Laboratory Manual for classroom adoption one generally expects it to contain among other features the following. (1) a choice of experiments which are representative of the field, (2) a choice of experiments which make possible the use of the laboratory equipment at hand, (3) clarity of instructions to subjects and experimenters, (4) profundity, clarity, pertinence, and inclusiveness of questions and exercises pertaining to the various experiments, and (5) choice and arrangement of references. It must, of course, be admitted that each laboratory has its own traditions, equipment, favorite experiments, etc Hence in evaluating the above features the particular complexion and needs of a given laboratory will naturally play an important role Taking cognizance of such qualification, Munn's *A Laboratory Manual in General Experimental Psychology* appears to me highly successful in fulfilling the proposed criteria Let us now consider the manual in the light of these criteria.

1. The manual contains 65 experiments which are divided as follows: emotional behavior, 3; aesthetics, 2; sensory processes, 19; perceptual processes, 6, attention and discrimination, 3, imagery and association, 2, reaction processes, 5, individual differences, 5; the learning process, 14, social psychology, 4; and animal psychology, 5. This numerical distribution appears to be quite well in agreement with recent experimental interest in the respective fields. Possible exceptions to this are the number of experiments devoted to animal psychology, individual differences, and emotional behavior. However, many laboratories have inadequate facilities for experiments with animals, and emotional processes require elaborate equipment for successful demonstration On the other hand the omission of Pearson's Product-Moment method for computing correlations, the somewhat inadequate presentation of graphic methods, and the omission of reliability equations in the chapter on individual differences may appear a weakness to some who consider the book for adoption Such and other minor omissions are, however, readily offset by the unusually large selection of 65 experiments which represent the older classical experiments as well as the more important recent ones

2 Taken as a whole Munn's experiments call for a considerable amount of laboratory equipment, more probably than a number of laboratories contain. But this feature is again offset by the wide choice of material. I have found it comparatively easy to adapt the manual to a rather modest supply of apparatus by instituting minor changes here and there and by substituting an occasional experiment from other manuals

3 The reviewer feels that Munn has been unusually successful in keeping the directions to experimenters and the instructions to the subjects concise without serious loss of clarity.

4 The questions and exercises pertaining to laboratory experiments are always of utmost importance because it is in this connection that the student best displays his understanding of the problem and his knowledge of the literature concerning the problem under investigation It is here also where the author of a manual best displays his orientation in the field of *Experimental Psychology*, and his ability to lift the most important facts out of the literature for the purpose of converting them into stimulating and instructive questions. Space, of course, would not permit one to examine all of the questions in the manual Hence I shall examine two experiments chosen at random for the purpose of pointing out some typical features of the questions in the book.

On pp. 41-41*a* we find an experiment on visual space perception which endeavors to present the factors of binocular vision, double images and stereoscopy. The following questions are introduced to sum up the results "1. What explanation of the results on binocular and monocular discrimination of distance are you able to offer? 2. How may double images be explained? Attempt to explain each of the phenomena observed. 3. How do you explain the phenomena observed with the stereoscope? 4 From your reading and general observation, what would you say are the chief cues upon the basis of which perception of tridimensional space is made possible?" These questions, when considered as a whole, appear to the reviewer a bit too general for an adequate exploration of the problems involved In connection with question 2, for instance, it might be well to call for a diagram demonstrating the occurrence of double images under the various conditions; also, to draw a diagram showing how the fusion of images occurs, when (*a*) the fixation point is the farthest of two parallel points, (*b*) when the fixation point is the nearest of the two To supplement the general question "How do you explain the phenomena observed with the stereoscope?", it might be well to add a number of specific questions The following may serve as examples: What factors enable one to get the impression of depth and distance from a single plane picture? How do these factors compare in importance with the binocular vision factor? What is the function of the lenses, the screen midway between the lenses, and the sliding carries of a stereoscope? What are the primary and secondary cues for depth perception in stereoscopic vision? In connection with this experiment it would also be well to devote a section to binocular fusion and rivalry

Another example of the generality of the questions is to be found in the experiment on Maze Learning on pp 81-81*a* The questions following this experiment concern a comparison of the maze learning and letter-digit substitution curves, plateaus, the physiological limit, the Vincent learning curve, relation of motor skill to intelligence, and the relation of time and errors in

maze learning. There are, however, no specific questions concerning the acquisition of the maze habit as such. Additional questions, like the following, might aid the student in comprehending more fully the various steps involved in maze learning. If one becomes confused in one trial after the learning has progressed to some extent does it tend to cause confusion in the immediately succeeding trials? Does the learning of the true path in the maze cause the blind alleys to be eliminated spontaneously or must one actually inhibit the entrance into blind alleys as well as try to keep in the true path? Do any parts of the maze seem more difficult to learn than other parts? How do kinaesthetic processes operate in maze learning? How may the fact be explained that "useless" movements tend to drop out (time and errors tend to decrease) as practice goes on, instead of persisting by habit?

5 In the choice of references Munn has drawn heavily from the more recent literature This probably is justifiable if not carried to the extent of omitting the older classical experiments

In the arrangement of the references Munn has again resorted to a good deal of generality He has placed all of the references at the beginning of a chapter, e.g, The Learning Process. This makes it difficult for the student to choose the literature pertaining to a given experiment To the reviewer it would appear more desirable if the references were given in connection with specific questions and exercises, even to the extent of giving page references which discuss the phenomena in question The possibility that with such an arrangement the insincere student would read only the pages referred to could be offset by assigning a greater number and variety of references

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Florence L Goodenough *Developmental Psychology* New York Appleton-Century, 1934 Pp vii+619

Those who are teaching courses in child psychology will welcome this book as probably the most useful text in the field The author has shown an extensive familiarity with the literature dealing not only in child psychology but with psychological problems in general The material touches upon an incredible number of problems about each of which many volumes have been written, but the author has shown discrimination in pointing out the salient issues so that the student is not lost in an account of a multitude of specific experiments which may have slight bearing upon the problem The literature on diverse topics has been thoroughly assimilated and is presented in a direct and comprehensible manner The cumbersomeness of direct quotations has been wisely avoided Prob-

lems about which there is vast theoretical controversy are discussed with lucidity and are woven into meaningful, practical illustrations of experiences which would probably constitute part of any student's daily life. There appear at the beginning of each chapter several leading questions aimed to provoke on the part of the student at the outset a questioning attitude.

After an introductory chapter on the "study of human development" and another on experimental methods of attacking psychological problems, the general organization of the book involves discussion of human behavior in large chronological periods, viz., hereditary background, prenatal period, the newborn infant, infancy proper, early childhood, later childhood, adolescence, adulthood, and old age. These divisions seem to imply that developmental processes and psychological problems are distinctive to these periods. There is, for example, a chapter on "How Older Children Learn" as if there was something in the learning process peculiar to this age level In fact the writer says that "children learn from the beginning but they learn casually, incidentally By the age of six or seven, however, a new element comes into his learning which will thereafter play a highly important part in modifying his behavior and extending his range of accomplishments From then on the child not only learns He *tries* to learn" She does not, however, show that the *trying* at this age is different from that indicated by an infant trying to learn to walk It seems to the present reviewer that the featuring of chronological periods is unfortunate since it must cloud the concept of development as an ever continuous on-going process.

The chief criticism of the book is an academic one. Just what should be covered under the title of "Developmental Psychology" is a matter of question Certainly it transcends human development. The human is only one phase in a long complex phylogenetic series. Perhaps a more appropriate title for this book would have been "Human Ontogeny"

Because the author has succeeded in eliminating a lot of excess material and presenting the salient issues in simple direct language this text will be of great benefit to the beginning student.

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Burt, C. The subnormal mind. London, New York: Oxford Univ. Press, 1935. Pp vii+368. $3 75

Fitz-Simons, M. J Some parent-child relationships New York: Teach. Coll, Columbia Univ, 1935. Pp xi+162 Cloth, $1.75.

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AN EXPERIMENTAL STUDY OF THE ONSET OF BEHAVIOR IN THE FETAL GUINEA-PIG

From the Psychological Laboratory of Brown University

C S BRIDGMAN AND LEONARD CARMICHAEL

I INTRODUCTION

In an earlier publication by one of the authors, dealing with the origin and development of motility in the fetal guinea-pig, the exact nature of the first responses of the fetus could not be definitely described because a sufficient number of animals had not been studied in the very first stages of motile life (7). The present paper reports a study of 47 fetal litters comprising 146 fetuses in the period immediately before and immediately after the onset of somatic motility

The problem of the nature of the first responses of the mammalian fetus is one of general significance for the whole science of behavior It is also at present a field in which the interpretation of observational data has led different investigators to divergent conclusions In this paper the status of the problem in terms of the work of active investigators will first be summarized briefly and then the findings of the present experiments, their interpretation, and their bearing upon the points which are at present controversial will be given

II PRESENT STATUS OF THE PROBLEM

The elaborate modern study of the relationship between the development of behavior and the development of the mechanisms upon which behavior depends may be considered to have begun with Coghill. The early part of the work of this investigator was summarized by him in 1929 (9) On the basis of his studies on the larval *Amblystoma,* Coghill holds that behavior develops as the gradual expansion of what is termed "a total pattern." This pattern is said to be completely integrated from the first. By a process termed "individuation" partial patterns or reflexes become separated, in a measure, from this unitary whole, as development progresses. Thus, special reflexes, such as independent movements of one limb,

occur first only as a part of a total pattern involving the whole organism. Later through individuation it is asserted that these apparently isolated responses acquire a measure of independence

Further, on the basis of such work as that of Child (8), Coghill holds that the primary conduction paths of the nervous system arise out of pre-neural gradients The first physiological stage in the development of motility is held to be one in which "the muscles can be excited to contraction by direct stimulation, as by the stab of a sharp needle, by mechanical impact or by electricity, but cannot be excited by light touch on the skin" (9). Anatomically during this period he further points out that there are both sensory and motor nerves in contact with their respective end-organs, receptors and effectors, but that the connecting mechanisms in the central nervous system have not yet fully developed. With the growth of cells in the floor plate of the medulla connection of the afferent and efferent mechanisms is effected and response to touch stimulation can be effected. The possibility is also noted by this investigator that in *Amblystoma* as well as in the toadfish, as described by Tracy (23), it may be that the efferent nervous system is functional before the afferent system Thus, after the independent effector stage there may be a stage when only the efferent neural mechanisms, stimulated endogenously, are capable of effective functioning. Coghill, however, notes that if this is true in *Amblystoma* its obvious appearance is masked by a dominating afferent system.

According to this same investigator the result of the neural mechanism just described on behavior is that, in *Amblystoma* at least, the first movement involves the trunk, next passive limb movement, and at length, after a day or two, local responses of the limbs "It is obvious, therefore," he says, "that the first limb movement is an integral part of the total reaction of the animal, and that it is only later that the limb acquires an individuality of its own in behavior" (9) That Coghill does not consider this description to be limited to *Amblystoma* but also to be applicable to man is attested by his statement that he is convinced that behavior develops in "man as it does in *Amblystoma* by the expansion of a total pattern that is integrated as a whole from the beginning and by individuation of partial patterns (reflexes) within the unitary whole" (10) That the extension of the pattern of development discovered in *Amblystoma* to mammals and man is still hypothetical will, however, probably

be admitted by all Yanase (33) and Strassmann (19) are quoted by Coghill in the same paper, from which the excerpt two sentences above is given, as reporting the earliest recorded human fetal response as limb movement. In this connection it must not be forgotten that the larval *Amblystoma* freely swims when even the place of its future fore limbs is marked only by barely perceptible nodules on the surface At this time, prior to its metamorphosis, *Amblystoma* actively swims by moving its whole trunk with its relatively great tail and its fin-like fold It is not surprising then that in this period in this organism, before lungs have developed, and when the limbs themselves are first growing, limb movement should be at first passive In mammalian fetuses the very first somatic movement does not take place until the limbs are relatively well formed, and it is not impossible therefore that the pattern of development discovered to hold for *Amblystoma* will not fit the mammal or man. Indeed, if one wished to look for a "recapitulation" of amphibian behavior in the mammal one would expect, by anatomical analogy, that such behavior would appear at a period before the limbs had developed, but unfortunately this is a period in which, because of its neuro-muscular mechanism, no mammalian fetus can move. It would therefore seem almost surprising if the mammalian fetus passed through the same stages in the development of behavior as does the larval *Amblystoma* during its metamorphosis

Following the work on *Amblystoma* by Coghill, a number of workers in this investigator's laboratory have attempted a similar study of the development of behavior in relation to its neural mechanisms in the fetal mammal. Swenson (20-22) and more recently Angulo y González (1-5) have studied in detail the onset and development of behavior in the fetal rat Moreover, work of this latter investigator indicates, he reports, that a sequence of development not unlike that found in *Amblystoma* can be traced in the developing rat fetus. He finds that movement first occurs about 378 hours after insemination in the rat fetus He reports that "this movement consists of a feeble lateral flexion of the head involving only the neck region The movement is very slow and of small amplitude" This movement then "progresses so as to involve first the fore limbs and later on the rump" It is further noted that "During the early stages of development the appendages move only with the trunk." At first, stimulation of the snout leads to "a total

mass reaction." Descriptively, however, this is primarily a lateral flexion of the trunk. It is only during later periods of development, this investigator holds, that specific reflexes appear. Even during these periods, however, the secondary or reflex movements are still "under the dominance" of the primary pattern of which they are initial components. Angulo y González further points out that motor nerves, of a sort to make possible limb movement, are functional before the sensory nerves in the fore paws can be stimulated tactually. Moreover, by experimental means he shows that an alteration in the metabolites of the blood stream can change the nature of these movements, presumably by direct action on the central nervous system, at a period earlier than that at which such movements can be exteroceptively aroused. In summary, then, it can be said that Angulo y González' results, based on his study of the onset of behavior in the rat fetus, and his interpretation of these results, are in close harmony with Coghill's description of the development of behavior in the limbless, free-swimming larval *Amblystoma* before its metamorphosis.

In a series of publications Windle and his collaborators have reported studies on a number of organisms of the development of behavior and its neural basis during the fetal period (16, 24-32). The general conclusions of this work have been different from those of Coghill and his associates just reviewed. In 1931 Windle and Griffin report that in the cat the first movement took place in a 16-mm. fetus as follows: "it showed momentary and almost imperceptible slight motility . . . the very slightest, slow, ventrolateral head flexion occurred and was repeated once or twice." In a fetus of 17 mm. it is reported, "Simultaneous with these neck-pectoral-trunk movements flexion of the fore legs occurred, and this was not a passive involvement only, but could be distinctly determined as a new active movement." In the anatomical study of these embryos the importance of the appearance of numerous sensory collaterals in the posterior funiculus fibers of the cervical cord at just the time that motility begins is emphasized. In a subsequent study, also using the cat, Windle, O'Donnell, and Glasshagle report that spontaneous movements were observed in cat embryos 14.5 mm. and 15 mm. long. These movements took place first in the fore limbs, then in the neck. Later "mass movements" develop. But, "Simple, local unit muscular contractions can be elicited a day earlier than spontaneous

mass movements" (30) Further, in summary of the elaborate histological study of the central nervous mechanisms of the cat fetus just at the onset of behavior the following statement is made: "Morphologically and physiologically, there is no evidence that the concept of a gradually expanding total pattern completely integrated from the beginning (Coghill, '29) can be applied to the first leg reflexes of the cat embryo" (26). Further it is pointed out that these movements "appear to be true, local reflexes." In a more recent study Windle, Minear, Austin, and Orr report an elaborate investigation of the rat fetus The results of this study are not in complete agreement with the results secured by Angulo y González summarized above In the study by Windle and his collaborators great care was taken to differentiate between the responses resulting from the direct stimulation of skeletal muscle and the onset of true neurally determined responses. By the middle of the 16th day after insemination (374 hours) rat embryos began to respond reflexly to various stimuli "Flipping the forelimb at times induced a quick outward and backward twitch of the limb as a whole or of its distal part, depending upon the size of the specimen This response was usually unrelated to any trunk movements" (29) Extension and flexion of the head, however, followed stimulation of the snout. That these fore-limb responses are true reflexes and not the result of direct stimulation of muscles, these investigators hold for the following reasons:

> They were (1) relatively quicker, (2) not necessarily moving the member as far as it was capable of being moved by maximal contraction of the muscle (3) A noticeable latent period usually appeared to follow the application of the stimulus, and sometimes summation of stimuli seemed to be effective when a single one failed (4) There was no marked tetanic quality of the response, the member returning quickly to the normal position (5) One response nearly always seemed to render a succeeding stimulus ineffectual for some moments, suggesting a long refractory phase (6) The response was quite stereotyped, regardless of where the stimulus was applied the plane of reflex movement was the same (7) Its presence depended *to a very great extent upon the physiological condition not* alone of the embryo but likewise of the parent rat These characteristics appear to be shared by the forelimb, head, trunk, and hindlimb reflexes in their earliest development (29)

In contrast to the conclusion of Windle that the first responses of the rat fetus are reflex in character must be placed a recent statement of Angulo y González (5). This investigator again re-asserts the view that the fetus passes through three stages in the early development of response—myogenic, neuro-motor, and sensorimotor. He also alleges, against Windle's fourth point above, that to minimal stimulation myogenic responses allowing quick relaxation to take place do, under certain circumstances, occur. Moreover, in an experiment reported in this study, a norm for the time required for the abolition of reflexes after curare had been injected intraperitoneally was established. Using this norm, it was found that after the time had elapsed which should have been sufficient to bring about the abolition of reflexes, light touching of the fore limb nevertheless still gave a response identical with that observed before the curare had been injected. On the basis of this experiment it is concluded that in the fetuses being studied stimulation of muscle brings about response in independence of the nervous system. The age of the fetuses on which the experiment was done is, however, not specified, and this is obviously a crucial point. If the fetuses in question are older than the ones in which first responses appear, the result would not necessarily be relevant concerning the nature of such very early behavior. Moreover, the exceedingly transient character of the first responses in cat, guinea-pig, and rat fetuses, as observed by the present writers and as emphasized by Windle, makes it seem unlikely that the experiment using curare could be carried out on the very earliest motile fetuses. It should also be emphasized that the first responses are apparently very easily influenced by the anesthetic which may have been applied to the maternal organism during the preparation of the fetuses for observation, and evidence in regard to this factor is not given in this last report of Angulo y González.

Beside the work just briefly reviewed, there have been some other studies which have an indirect bearing on the present problem. Notable in this connection is the work on chick embryos which was carried on by Kuo (14, 15) and Orr and Windle (16), but this need not be summarized here. Coronios (11), working in the Brown Laboratory, found in a study begun in 1928 on the development of behavior in the cat fetus that, in the very onset of such behavior, neck flexion, with possible accompanying fore-limb flexion, was the first observable movement. In a previous study one of the present

writers reported that the first movement of the guinea-pig fetus seemed to be a lateral flexion of the neck and a possibly independent movement of the fore limbs (7). This conclusion was made tentatively because it was based upon too few observations.

The present investigation was undertaken therefore in order to complete the previous study and to settle, in so far as possible from behavioral observation, the question, "What is the nature of the first fetal response of the guinea-pig?" The hope of the investigators was also that indirectly the answer to this question might be expected to give additional evidence concerning the question as to whether the *onset of behavior in mammals is best to be considered in terms of mass-movement involving the total organism or in terms of discrete reflexes.*

III. Experimental Procedure

In general, the same experimental procedures as those described in a previous paper by one of the present authors were used in this study (7). By the employment of these techniques it is possible operatively to expose for observation and motion-picture recording each fetus as it is to be studied. This is accomplished under relatively normal conditions and after the maternal organism has had ample time completely to recover from the anesthetic applied in the preliminary operation. Both of the authors were present at each experiment reported in this paper and the dictated protocols were agreed upon in each case by both.

In general, the following observational procedure was carried out on each fetus studied. (1) The uterine vesicle was opened and the fetus exposed without injuring the amniotic sac. Observations were made at this point. (2) The fetus was then observed in the clear liquid of the sac which was itself under the liquid of the bath. This observation occupied varying lengths of time up to several minutes and during this period no stimulation of any sort was applied, save that necessarily induced by the change of pressures caused by the operation and, although this is probably irrelevant, by the strong lights which were directed on the bath. (3) If "spontaneous" behavior occurred, this was noted and photographed by the special moving-picture camera arrangement previously described (6, 7). When the fetus had become quiet, or if no spontaneous movement appeared, after a short waiting period, external stimulation was

applied first by pressing and second by lightly stroking the outside of the amniotic sac Ordinarily this was first done so as to change the pressure relations of the liquid surrounding the fetus, but not directly to touch it After this sort of stimulation the fetus was more directly stimulated at various points by pressing down but not puncturing the sac in such a way that the fetus was directly stimulated Stimulation of this sort was customarily applied to various cutaneous zones In each case the resulting behavior was recorded in protocols and in motion-picture records (4) After behavior could no longer be elicited, but ordinarily while the heart was still vigorously beating, the fetuses were marked for identification and placed in a fixing solution of 5 per cent formalin (5) In selected fetuses at varying periods electrical stimulation from an inductorium was applied by suitable electrodes to various muscle groups (6) After at least six days in the fixative the fetuses were weighed and measured, and this data added to the protocols. The procedure used in these measurements was thus constant and, in spite of changes in height and weight which follow fixation (12, 13, 18), it was assumed that a better relative scale could be secured in this way than by attempting to measure the soft fetus in the salt solution immediately after removal from the amnion. As only a relative scale was required, no corrections of the measurements have been attempted Weighing was done on a chemical balance to the nearest 10 milligrams Although the fetus continually lost weight through evaporation while being weighed, a consistent method was used in all cases so that an approximately constant loss was suffered by each fetus.

The crown-rump length of each fetus was determined by the use of vernier calipers with inside and outside jaws and of outside calipers with screw adjustment The fetus, placed on a black background, was measured by both instruments. A fairly constant error of 2 to 3 mm generally existed between the two measurements This suggested a constant and not a variable error The individual lengths listed in the tables are the averages of these two readings. Length is always given in tenths of a millimeter, and weight in one-hundredths of a gram.

Table 1 lists the copulation age in hours, the litter averages of crown-rump length and weight, individual crown-rump lengths, and an indication of the behavior exhibited by each of the 146 fetuses

TABLE 1

COPULATION AGE		621	622	622	623	624	624	625	625	628	629	629	631	633	635	635	[illegible]	636
LITTER	C-R LENGTH	162	180	171	171	171	177	173	172	174	172	163	167	172	179	185	[illegible]	191
AVERAGE	WEIGHT	46	45	39	58	81	70	61	57	61	61	52	55	60	68	68	[illegible]	71
NUMBER IN LITTER		3	3	4	4	3	2	4	4	3	4	2	2	3	3	3	1	3
INDIVIDUAL CROWN-RUMP LENGTH		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NON-MOTILE		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NECK FLEXION	DORSAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	VENTRAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	LATERAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FORE LEG	FLEXION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	EXTENSION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	INDEPEND. MVT.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TRUNK FLEXION	LATERAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	DORSAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	VENTRAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HIND LEG MOTILITY		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

COPULATION AGE (CON'T)		636	636	638	638	638	639	640	641	641	643	643	646	647	650	661	661
LITTER	C-R LENGTH	178	186	175	176	180	185	187	184	181	175	184	174	189	198	185	187
AVERAGE	WEIGHT	70	66	82	81	84	76	72	70	70	83	89	55	73	83	69	76
NUMBER IN LITTER		5	3	4	2	4	3	3	3	3	4	4	2	3	3	2	3
INDIVIDUAL CROWN-RUMP LENGTH		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NON-MOTILE		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NECK FLEXION	DORSAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	VENTRAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	LATERAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FORE LEG	FLEXION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	EXTENSION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	INDEPEND. MVT.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TRUNK FLEXION	LATERAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	DORSAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	VENTRAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HIND LEG MOTILITY		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

COPULATION AGE (CON'T)		662	664	666	670	671	671	678	688	697	701	705	707	712
LITTER	C-R LENGTH	206	204	202	212	207	221	217	213	231	236	231	224	238
AVERAGE	WEIGHT	97	83	98	108	105	118	118	118	115	132	145	119	145
NUMBER IN LITTER		3	2	3	4	4	3	4	3	4	3	4	3	3
INDIVIDUAL CROWN RUMP LENGTH		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NON MOTILE		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NECK FLEXION	DORSAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	VENTRAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	LATERAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FORE LEG	FLEXION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	EXTENSION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	INDEPEND. MVT.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TRUNK FLEXION	LATERAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	DORSAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	VENTRAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
HIND LEG MOTILITY		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

included in the 47 litters examined in this study. The litters were found to have a range of crown-rump length from 16.0 to 23 8 mm., and a weight range of from 45 to 1.45 grams. The age range, 621 hours to 712 hours, comprises an observation period of 91 hours The litters are not distributed regularly throughout this period, however, since more than half fall within the first 20 hours.

Inspection of Table 1 indicates that copulation age is not an absolutely accurate basis on which to predict behavioral capacity,

since certain older fetuses remain non-motile, or exhibit less advanced behavior than certain younger ones. Length and weight in the case of a few litters provide a better index of behavioral development than does age. This is not always true, however. The inconstancies between measures of development, such as age, length, and weight, and the actual observed behavioral development are probably due to a number of factors, including unselected genetic stock, and in the case of copulation age, variations in the time required for fertilization to take place after copulation (34). At the age studied in this work, the fetal organism is undoubtedly susceptible to slight changes in its environment, either internal or external, and this fact has probably influenced adversely the regularity of the results. This variation must always be remembered when discussing behavioral development in terms of any one of the three independent variables, age, length, and weight.

Position in the uterus was found to have no apparent constant effect on fetal development. There was a slight but probably not significant tendency for the last fetus examined in a litter to be less active than the ones examined earlier, but in some cases the last fetus was active while intermediate ones were inactive.

In view of these facts, it has been decided to discuss the behavioral development in terms of copulation age, keeping in view, at the same time, the imperfections of this measure.

As noted in Table 1 certain fetuses were non-motile, in the sense that no active responses were observed to be made by them. That is, in such organisms responses involving skeletal muscle contraction, save as a result of special electrical stimulation, did not appear. Two types of activity did show themselves in such organisms, however. The first of these was passive head and body vibration brought about by the beating heart. Movements of this sort were observed in non-active fetuses, both before the onset of motility and after. These passive movements could also be still seen in a number of fetuses which had passed through a period of true behavioral activity, but from which no further active responses could be elicited. The second of these pre-reflex types of movement was the result of myogenic stimulation by electrical means. No complete systematic investigation of myogenic contraction was carried out, but sufficient observations were made to determine its presence to electrical stimulation in non-motile fetuses, and in fetuses which had just previously been

active, and to identify certain of its characteristics In early fetuses faradic stimulation was used successfully in this study in eliciting direct muscle responses, whereas other types of stimulation such as stroking, flipping the limb, and tapping did not seem ever to have been adequate to elicit such responses It should be emphasized that fetuses exhibiting no active movement would respond to faradic stimulation and that fetuses from whom no further active movements could be elicited by tactile stimulation also gave myogenic contractions. Muscle groups which had not been contracted during what we wish to call the period of true motility also responded to electrical stimulation.

The facts summarized in Table 1 show that roughly with increasing age the number of fetuses to show skeletal muscle responses increases and the number of motor mechanisms to be active in such fetuses also increases All of such responses are held by the writers to be of the reflex type. The non-appearance of behavior in the youngest fetuses may be attributed to lack of development, especially of the nervous system, but the fact that one or more fetuses in litters, the other members of which had shown activity, were often inactive, although showing all the external signs of being ready for activity, suggests that even in the earliest fetuses unknown factors beside mere neural immaturity may influence the failure of behavior to appear Since this study deals with so large a number of litters, it is felt that such variable factors may be considered to have been largely ruled out Table 1, therefore, may be taken to present a reasonably typical picture of the time of onset of behavior in this organism It cannot be emphasized too strongly, however, since neither copulation age nor height nor weight is an absolute index of behavioral capacity, that it is impossible to say, for example, whether neck or fore-limb flexion is really the first movement to be observed in these organisms. The full qualitative description of the very first responses of the guinea-pig fetus summarized under the headings of movement of the neck and fore limbs and trunk in Table 1 is by no means a simple task It should also be noted that in the protocols many amplifying descriptions of the early responses are given The categories used in the table seem to us to be the most adequate phrases available, but at best they are incomplete descrip-

tions of the movements as described from actual observation and from the study of motion-picture records[1]

Table 1 also shows that the very first recorded movement occurred in a fetus 622 hours old. Previous investigators, Preyer (17), Yanase (33), and Carmichael (7), had set the onset of behavior from 24 to 48 hours later than this. This first recorded movement was a simple ventral flexion of the neck which brought about a very slight bowing of the head In a fetus not significantly older, however, a fore-leg movement which involved a slight but active flexion, with articulation at the shoulder, occurred In this same fetus a slight dorsal flexion of the neck, or, as it is sometimes called, head extension, also took place. That these two responses were not part of any general pattern of behavior, however, is demonstrated by the fact that they did not occur at the same time Lateral neck flexion first took place in another fetus of this same age

The very transitory character of these first movements must be given strongest emphasis. Typically in the youngest fetus they are seen but once. Therefore every effort had to be made to have them watched by two or more experienced observers and to have them adequately recorded in motion pictures. That these first movements are not myogenic, but are rather true reflexes is suggested by this very transitory nature In the youngest fetuses movement takes place only after touching the outside of the amniotic sac in such a manner as to stimulate the fetus One or at most two or three responses can be elicited by such stimulation, and there is always a refractory period of a number of seconds between successive effective stimulations In very early fetuses after the amniotic sac had been removed no response of any sort, save to electrical stimulation, was elicited in the material of this study It seems, therefore, that the first response, or at most the first two or three responses, so alter the organism (and presumably the central-nervous-system connecting mechanism) that a long refractory, or indeed possibly better, fatigue period, is set up. The changes which take place in this period in any case are of such a permanent sort as to make further stimulation and response during the experimental period impossible

It seems, therefore, quite incredible that curare could be administered to fetal guinea-pigs during the very early motile period in

[1]Funds for the purchase of this film were generously provided by a grant-in-aid of research by the National Research Council

the way described above by Angulo y González. After the necessary disturbance of the animal brought about by the injection of the drug and after the stipulated waiting period, no true reactions of the transitory sort which alone occur in this period could possibly be expected. In this connection, it should be noted that, after the one or two neck reflexes or limb reflexes have occurred, the muscle of neck or limb still seems, to inspection by the lens, to be in completely normal condition, as fetal circulation, indicated by a strongly beating heart and a pink color, always continues during this period in any fetus whose record is used It is also just as possible to stimulate the limb electrically after what we believe to be reflex movement has apparently been forever abolished as it was before such abolition occurred

TABLE 2

Period	I	II	III	IV
Hours	621-631	632-642	643-666	667-712
No fetuses	38	43	29	35
Per cent active	19	51	45	80
Number active	12	22	13	28
Neck flexion				
Dorsal	9	13	10	2
Ventral	5	4	1	3
Lateral	4	16	6	18
Fore leg				
Flexion	9	20	12	25
Extension	1	4	2	5
Independent	3	12	8	24
Trunk flexion				
Lateral	0	0	4	11
Dorsal	0	0	0	1
Ventral	0	0	0	2
Hind-leg motility	0	0	0	6

Table 2 presents in a different form a summary of part of the data found in Table 1 In presenting the results of the investigation the fetuses studied have been grouped into four periods according to age During the first period, 11 hours in extent, it is seen that, as indicated above, dorsal neck flexion and fore-leg flexion had an equal frequency of occurrence, each being observed nine times

Directly after this first period changes in behavior may be noted These changes are summarized in the data listed under Period II, which was also eleven hours in extent.

The appearance of trunk flexion occurred at the 643rd hour, and this type of response was seen with gradually increasing frequency in later litters. Thus, although the relations between dorsal and lateral neck flexion and fore-leg flexion remained essentially the same during the third period, the occurrence of lateral trunk flexion with lateral neck flexion made this sort of behavior more and more outstanding With the almost complete disappearance of dorsal flexion after the 666th hour, the only other component of behavior with a comparable frequency during the fourth and last period of 46 hours was independent fore-leg flexion.

Hind-leg movement was first seen in a fetus 676 hours old, and ventral and dorsal trunk flexion occurred at 697 and 705 hours respectively Of these, hind-leg motility undoubtedly would have increased greatly in frequency with further observations, as has been shown in a previous study by one of the writers (7). During the examination of the oldest litters, a few flexions involving the more distal joints began to appear, but here again the period of observation was not sufficiently extended to allow further investigation of this aspect of development

The description presented in the paragraphs above has offered some indication of the frequency of occurrence of various types of behavior, but little has been said concerning the extent to which these elements appeared together. Although each element was readily identifiable at all times, each did not always appear separately. On the contrary, simultaneous or sequential occurrence of separate behavior acts was sometimes noted in the behavior at all ages. It was found in the later fetus that almost any movements, save those involving antagonistic muscles, might appear at the same time, and that even responses dependent upon the activity of antagonistic muscles might appear in immediate succession. Certain of these combinations of responses appeared frequently enough, and in a sufficiently constant form, to warrant the use of the term "pattern" in their description Nothing more need be implied by this term, as used in this sense, than that the same or approximately the same behavior or sequences of behavior were observed from time to time. It should be remembered, however, that at no time during the development observed did behavior that can even in this limited sense be called "patterned" entirely take the place of independent movements

The first movements to occur simultaneously were dorsal neck flexion and an independent fore-leg flexion. Thereafter, throughout the period studied, a characteristic type of motility involved a concomitance of leg flexion with whatever sort of neck movement was predominant at the time. But it must be emphasized that these leg and neck movements occurred alone a sufficient number of times at all ages to demonstrate that they were not in any sense one "general" movement.

The next "pattern" which may be described is that formed by the *combination of dorsal and lateral head movements.* This frequently took place in such a way that apparently the head was slightly rotated with respect to the body. As intimated above, leg movement was also often combined with these responses. Here again each component of this pattern was seen separately, even when the "pattern" was statistically at the height of its frequency.

With the development of lateral flexion to the almost complete exclusion of other types of head movement, as described previously, the patterns mentioned above no longer appeared. The most characteristic behavior which now appeared was a combination of lateral neck flexion and fore-leg flexion. It should again be noted that in this pattern, as well as in the others in which leg flexion played a part, the leg component often had no definite temporal relationship to the other movements. That is, the leg movement might follow or be followed by the neck movement, or the two might occur simultaneously.

Probably the most consistently appearing "pattern" was that of trunk movement occurring with a similar type of neck flexion. Even in this case invariability of occurrence did not make itself apparent, since, as described above, separate, isolated, localized contractions of the trunk alone or of the neck alone did appear.

Another very consistent sort of behavior was formed by the sequential combination of lateral flexions to one side and then the other. Such bilateral flexions which may be described as "C–" and "reverse–C–" movement or as the beginning of "S–" movement appeared often when a lateral flexion took place which also included trunk flexion in the older fetuses of this study.

Fore-leg extension was similar to fore-leg flexion in that it appeared separately and in conjunction with the prevailing head movements. Hind-leg motility, the few times it was observed, occurred

usually with trunk, neck, and fore-leg movement, but independent responses were also probably noted, although the frequency of such reports is not such as to make the observation conclusive.

In the very earliest stages, the duration of the period of active movement was, as has been noted, extremely short, being limited at times to the elicitation of a single weak response As the age of the fetuses increased, the period of motility became longer, reaching several minutes toward the end of the period here studied The movements, moreover, besides exhibiting the development described in the preceding sections, gradually increased in magnitude.

In the present study, so-called "spontaneous behavior," that is, responses not resulting from any stimulus directly applied by the experimenter, did not appear until after stimulus-released behavior had been observed. Movement in response to stimulation appeared as noted as early as the 622nd hour, but spontaneous behavior did not appear regularly until after the 636th hour. It is important to note that when this so-called spontaneous behavior did appear it fell directly into the categories of neck and limb reflexes already described. A characteristic type of spontaneous behavior was, for example, a single fore-leg flexion without any other observable movement The finding that "spontaneous" behavior followed in time stimulus-released behavior contradicts the previous finding of one of the authors (7) The previous statement either failed correctly to interpret the stimulation resulting from opening the uterus or was based upon too few organisms.

IV Conclusions and Discussion

On the basis of the foregoing results, certain of the questions concerning the nature of the first responses in the fetal guinea-pig can be answered, and others fruitfully discussed

1 Prior to the onset of behavior in the fetal guinea-pig, myogenic contractions can be elicited from certain muscles. That these early responses are truly myogenic, and not sensory-motor responses, there is little doubt, because of their character, particularly as compared to later movements.

2 Active behavior in the fetal guinea-pig begins in the last hours of the twenty-fifth day Previous observers had placed the onset at least one day later than this

3 True behavior, that is, response that results from stimulation, and which is secondarily induced by nervous discharge, can be elicited 10 to 14 hours before "spontaneous" behavior appears. These stimulated responses are of a sufficiently different character from the earlier myogenic contractions to be classified as active, i e., involving neural activity The differentiating characteristics can be summarized, as was true in the case of myogenic contractions, by emphasizing certain of the criteria of the reflex summarized by Windle. In this study behavior taking place after a very long latent period often followed stimulation This period was apparently much longer than any of those reported in the rat by Angulo y González, in which myogenic contractions to just adequate stimulation were determined to have a latent period (5) A second criterion was fulfilled by the responses observed in this study, in that they could either not be obtained successively or, if elicitable more than once, were only so elicitable after a long latent period. Third, the active responses given upon stimulation were always the neck, limb, or trunk responses already described, whereas responses to faradic stimulation might involve entirely different movements. Dependence of these early responses to stimulation upon the condition of the parental and fetal organisms, another of Windle's criteria, is attested by their highly transient nature Since these responses soon disappear, yet the responses to faradic stimulation persist, the conclusion seems warranted that the former are of a different nature from the latter, and that this difference is connected with the activity of the nervous system. Were the curarization test of Angulo y González applied to these responses in the guinea-pig, it is certain that the early reflexes would disappear, since none of the earliest responses could be aroused by any means save electrical stimulation after the time necessary for such an experiment to be performed had passed

In addition, it may be noted that the stimulation generally used in this study was not of the sort that had been found effective in bringing out myogenic responses. The fact that muscles not included in the active movements could be induced to contract to faradic stimulation is added evidence for the difference in character of these two types of responses Also, spontaneous behavior when it arose was little different from the earlier stimulated behavior

The nature of spontaneous behavior is directly related to the problem discussed above The correspondence between responses to

general stimulation and spontaneous responses, along with a knowledge of the conditions under which the fetus is delivered from the uterus, have resulted in a belief on the part of the present writers that much of the so-called spontaneous behavior observed is due to proprioceptive or pressure stimulation attendant upon such delivery Stimulation resulting from this operation would correspond rather closely to the intentionally applied stimulation, and this interpretation would aid in explaining the similarities between behavior arising in the two situations It is realized, however, that this explanation is not adequate to account for all spontaneous behavior, since much of it occurred only after a relatively long period of quiescence following the delivery of the fetus from the uterus In this connection the strong lights of our observation apparatus may possibly have been effective stimuli, or some unrecorded vibration may have been important.

The appearance of spontaneous behavior at a time later than the onset of behavior in response to applied stimulation may, it seems, be interpreted as favoring an activated receptor mechanism for the origin of spontaneous behavior This mechanism might be either proprioceptive or exteroceptive Such a receptor mechanism might not be sensitive enough, possibly because of incomplete central nervous system connections, to be stimulated by the changes occurring upon delivery from the uterus, such as circulation and pressure changes, but nevertheless open to stimulation by more vigorous experimentally applied stimuli Further investigation of such spontaneous behavior should prove profitable, and might lead to a better understanding of what is now typically called "drive," and its relation to exteroceptively stimulated behavior. In any case it is obvious that conclusions based upon the important observation on the significance of endogenous stimulation in the onset of behavior of the toadfish, made by Tracy, must be applied with great caution to the present mammalian fetus.

4 The first active responses of the fetal guinea-pig are definite in character, and involve movements of the head, brought about by contraction of the neck muscles, and of the fore leg. The evidence is as yet inconclusive concerning which of these components arises first.

5 It is seen that, from the earliest period, the neck and limb responses occur sometimes together, and sometimes independently,

and that throughout the developmental period studied, independent elements of behavior are present at all times. That is, no gradual progressive "individuation" of the specific responses out of a total pattern is seen Although certain patterns of behavior are observed, no one of these can be said to "dominate" the behavior of the organism It may well be that the occurrence of "patterns of behavior" in response to stimulation, as reported by some observers, is explained by the nature of the stimulus used and the proprioceptor or "movement-produced" stimulation brought about by the initial responses themselves rather than by any "pattern" in the central nervous system.

6 Because of the simple and specific nature of much of the earliest behavior of the fetal guinea-pig, it is thought that these responses may advantageously be described as reflexes. Moreover, no need to use such words as "generalized," "totally integrated," or "non-specific" in the description of this behavior has arisen The term reflex is employed in spite of a realization of the difficulties involved in defining it in a way that will satisfy all students. This word is here used to imply inferentially the presence of sensory, central nervous and motor nervous elements in the mediation of the relatively simple responses to stimulation which are described in this paper.

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THE COMPARATIVE BEAUTY OF THE FACES OF HIGHLY INTELLIGENT ADOLESCENTS

From the Department of Psychology of Teachers College, Columbia University

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THE PROBLEM STATED

How do intellectually gifted persons compare with the population at large, in regard to beauty of the face? This question has been much discussed, but little studied It is popularly supposed, as set forth in cartoon, caricature, and story, that a high degree of intelligence tends to exclude beauty of the person, especially in the case of females. A collection of cartoons covering this subject may easily be made, in which the highly intellectual person, child, youth, or adult, is pictured as characteristically bespectacled, solemn, high-browed and "sicklied o'er with the pale cast of thought."

A study of the relationship between beauty and intelligence, involving college students, made by Hollingworth (3) yielded a positive correlation of .40 between beauty as estimated by associates of two years' standing, and intelligence as elicited by scores on tests This amount of positive relationship between beauty and intellect, obtained on a group so restricted in the latter trait, leads to the hypothesis that between groups widely separated in respect to intelligence, distinct differences in beauty would be expected to appear, in favor of the more intelligent.

Also, recent studies by Mohr (7) and by Mohr and Lund (8) revealed that ratings of 25 college students by 25 other college students for beauty, or physical attractiveness, correlated positively though slightly with scholarship and with intelligence

The present study was restricted to beauty of the *face*, head and shoulders entering also in a minor way into the composition of the picture. It would be desirable to study by the methods here used the actual faces of persons proved to be of high degrees of intelligence This is, however, scarcely feasible for various reasons. We wished to employ the order-of-merit method, and the method of rating. For each face appraised we wished to have ten

different judges who would be total strangers to those judged, in order to avoid the "halo" effect (9) which enters into the judgment of any trait when those judged are personally known to judges, or when any characteristic of the judged is known. To bring together repeatedly for purposes of comparison forty or more persons is not feasible. Furthermore, persons do not readily submit voluntarily to the embarrassment of repeated and long continued comparative inspection by strangers.

All things considered, the best material for our purposes was decided to be photographs, made uniformly, unretouched, and large enough to show details of physiognomy clearly. In photographs, certain elements of the person are lost, e g., color and movement There remain contour, shape, proportions, ensemble of features, and facial expression to form the basis of impression upon the beholder These elements had uniform opportunity to appear in both of our comparative groups.

The Meaning of Beauty

Beauty is hard to define for those about to judge it. Basically, beauty is a psychological experience of the beholder Standards of beauty vary greatly from person to person and from period to period. To avoid argument about taste, and to cover as completely as possible the concept we ourselves had in mind, i. e , the attractiveness of the face, we used three terms in instructing our judges—"good looks," "physical attractiveness," and "beauty "

Blonsky (1), recently questioning persons of various ages as to what beauty of a human being is, elicited that beauty lies in "A healthy, young, mentally and physically strong personality " "This is, bio-psychologically considered, the highest type of person It is *the ideal-type It is the beautiful human being* *Human beauty* lies in that which we recognize as biologically and psychologically the highest type of person, namely the most worth while person "

When asked what constitutes human ugliness, the replies of respondents easily grouped themselves under a few categories For adults (with whom we are concerned in our study as judges) four classifications were found: (1) the morally degraded, (2) the dirty and dusty, (3) those of bestial appearance, (4) the sickly.

We did not discuss the standard or criterion of beauty with our

judges, although some of them (especially the Chinese who later judged one of our series for another purpose, and are referred to in connection with our conclusions here) raised the issue. Each was directed to render his appraisals according to his own interpretation of "physical attractiveness," "good looks," and "beauty."

Selection of the Subjects

The Highly Intelligent Group. In 1922, a group of young children, then 7 to 9 years old, testing between 135 IQ and 190 IQ (S-B) was brought together at Public School 165, Manhattan, in New York City (2). Fifty-six of these children stayed together for three years, in the elementary school, and became permanently known to those who had had their education in charge. When, in 1929, they were being graduated as adolescents from senior high schools, each of them was invited to have a photograph taken "for purposes of the study of photographs." Ninety per cent of these adolescents were 14 or 15 years old in 1929, when photographed. The remainder were either 13 or 16 years old. The median IQ (S-B) of the 40 who were photographed was 152, the median for the whole group being 153.

Such a group of adolescents is ideal for the study of the matter here under consideration, for they had been selected years previously with great care by individual mental tests, at a time when no interest whatever was taken in physiognomy. They were selected in childhood on two bases only, neither of which concerned their beauty (1) they must achieve at least 135 IQ (S-B), (2) they must have parents' permission to attend Public School 165, Manhattan. Mental tests are uninfluenced by beauty, and probably the same is true of parents' permission. In 1933, these persons were again tested, and were found to rate as adolescents in the top centiles of the adult population (4), the superiority revealed in childhood being thus proved not to be evanescent.

The Control Group. The subjects of the control group were not selected until 1930, and were never personally seen by the investigator. They were found in the following way. Between 1922 and 1930, Public School 165, Manhattan, had become a junior high school, and the class being graduated therefrom each year was of age equal on the mean to that of the adolescents above 135 IQ,

whose photographs had been obtained in 1929. Being from the same school, they represented the same racial stocks as those found among the latter

To find a suitable control group, representative of ordinary intelligence, among these pupils, we made selections upon the following criteria (1) to be 14 or 15 years old; (2) to be of the white race; (3) to fall not below 90 IQ nor above 110 IQ, by the group tests given in this school, (4) to consist of 13 boys and 7 girls (corresponding to the proportion of boys to girls obtaining in the group of primary interest)

With these criteria as guides, we took the register of pupils about to be graduated from Junior High School 165, Manhattan, and went through the names alphabetically arranged, checking each pupil corresponding to our criteria, until names had been recorded of all meeting the conditions Then letters were issued to these 37 pupils and their parents by the principal of the school, requesting the use of their photographs for purposes of educational research Of the 37 addressed, 23 granted permission for the use of photographs These were checked for racial derivation, and their correspondence with the racial origins of our gifted group was verified.

Description of Photographs

The photographs of both groups, gifted and controls, were taken by the same photographer, with the same camera, in the same studio, with the same lighting, in the same way, were printed on the same photographic paper and were made up in the same style of folder. All subjects were photographed in ordinary indoor clothing, without hats. All photographs were 8x10 inches, and were finished in dark gray All were of head and shoulders, to the same extent All showed both eyes of the person photographed.

The focus of the camera upon the face was not mathematically prescribed, but was left, within limits, in all cases to the photographer. The limits of focus prescribed were that no profiles should be taken, and that both eyes must be fully visible in every photograph. Under these limitations, the photographer took two proofs of each subject, and the investigator chose between the two the one which seemed clearer in every detail. No retouching whatever was done on any photograph.

As a check upon the amount of face exposed in the comparative groups, the visibility of the ears was determined for every subject. These results appear in Table 1.

TABLE 1
VISIBILITY OF THE EARS IN PHOTOGRAPHS OF THE COMPARATIVE GROUPS

	Series I Adolescents of IQ 135-190	Adolescents of IQ 90-110	Series II Adolescents of IQ 135-190
Right ear visible	3	4	1
Left ear visible	4	3	3
Both ears visible	*6*	*6*	9

Furthermore, in the case of boys, the angle from which the camera was focused was ascertained by measuring the distance in mm. from the point midway between the eyebrows to each edge of the head The greater distance divided by the smaller yielded a ratio, indicating the angle. A ratio of 1.0 would show that the subject photographed was squarely facing the camera This measurement was not reliable in the case of girls, because of the various arrangements of the hair. The results for the 13 boys of each series and for the controls appear in Table 2, showing about equal amounts of various angles of focus in all comparative groups. By inspection, the girls seemed to be posed at the same angles of focus as the boys

AVOIDANCE OF FALLACIES OF SELECTION

The Highly Intelligent Group There being no compulsion upon the highly intelligent adolescents addressed, not all responded to the invitation to be photographed. Only 40 of the 56 did so This failure to obtain a complete response created the probability of a fallacy of selection The 16 "missing" individuals might well be those who regarded themselves as inferior in appearance, or might be selected on some other basis which would render the 40 who participated unrepresentative of their intellectual group, as concerns beauty.

To determine the extent of possible selection, judgments of beauty were at hand for the total group of the highly intelligent, obtained as follows

TABLE 2

SHOWING BY RATIOS THE ANGLE OF FOCUS OF THE CAMERA UPON THE FACES, IN ALL COMPARATIVE GROUPS

(boys only)

On the scale used, 1 is the highest degree, 3 is the average degree, and 5 is the lowest degree of attractiveness

Ratios	Series I Adolescents of IQ 135-190	Adolescents of IQ 90-110	Series II Adolescents of IQ 135-190
1.2	1		1
1.3	1		
1.4			
1.5	1		
1.6	2		
1.7	1		1
1.8		1	3
1.9		1	
2.0	1	2	1
2.1		2	
2.2		1	3
2.3		2	3
2.4	2	1	
2.5		1	
2.6			
2.7	2		
2.8	1		
2.9		1	1
3.0		1	
3.1			
3.2	1		

The 56 adolescents were in 1929, when their photographs were taken, distributed among sixteen different high schools. In every case judgments of "beauty" were obtained (5) by securing ratings from two teachers independently, on a scale of degrees of beauty from 1 to 5, 1 being "very beautiful," 3 being "average," 5 being "very unattractive." The appraisal of each judge could thus be obtained in degrees. Combining the two independent judgments thus rendered, the score for "beauty" was determined which was used to distribute our sample of 40 against the total group invited. The distribution yielded the means and medians which appear in Table 3

From this comparison it appears that the forty adolescents whose photographs were studied were truly representative as concerns

TABLE 3

SHOWING THE ATTRACTIVENESS OF THE SAMPLE OF HIGHLY INTELLIGENT ADOLESCENTS COMPARED WITH THAT OF THE TOTAL POPULATION FROM WHICH IT WAS DERIVED, ACCORDING TO THE JUDGMENTS OF HIGH SCHOOL TEACHERS

Our sample ($n=40$) is representative of the total group ($n=56$)

Adolescents of IQ 135-190	n	Mean of teachers' rating	A D.	Median of teachers' rating	M V
Sample studied	40	2 40	±0 50	2 40	±0 45
Total group	56	2 40	±0 50	2 35	±0.35

beauty of the total group of those addressed, in the judgments of high school teachers who knew them well, at the time the photographs were taken.

The Control Group of Ordinary Intelligence In the case of the control group, there existed the same probability of a fallacy of selection, since some of those eligible and invited did not respond. This difficulty was approached by securing from the photographer who photographed the entire graduating class from Junior High School 165, Manhattan, photographs of one hundred per cent of the graduating class from which our respondents were derived. There were 95 pupils in the group who were of the white race These 95 photographs were then submitted to six well-educated adults, who judged them independently of one another, according to the following instructions

> Please sort these photographs of adolescents into 5 piles, on the basis of good looks (beauty) Into the first pile put those whom you would regard as the best quintile, in the second pile, those next to the best, etc, till in the fifth pile you have those rated by you as the least good looking fifth (quintile) of the group As there are 95 photographs, you will have 19 in each of your piles when finished First distribute the boys Then distribute the girls. Please signify when you have the 5 piles completed

According to the composite judgment thus rendered, the twenty photographs finally selected in the formation of our control group were fairly representative of the total population from which they were derived, rating as in Table 4 A mean quintile rank of three would indicate a perfectly representative sample of the 95 gradu-

TABLE 4

SHOWING THE ATTRACTIVENESS OF THE SAMPLE OF ADOLESCENTS OF ORDINARY INTELLIGENCE COMPARED WITH THAT OF THE TOTAL POPULATION FROM WHICH IT WAS DERIVED, ACCORDING TO THE JUDGMENTS OF SIX ADULTS

Our sample (n=20) is representative of the total group (n=95) A score *of 3 is indicative of exactly typical attractiveness.*

Subject	Score	Subject	Score	Subject	Score
4*c*	3 16	48*c*	3 33	*g*5*c*	4 66
10*c*	3 50	51*c*	3 33	*g*6*c*	1 83
14*c*	1 66	54*c*	2.16	*g*15*c*	1 50
21*c*	3 66	60*c*	1 66	*g*20*c*	1.50
40*c*	3 33	69*c*	4 00	*g*21*c*	4.16
44*c*	2 50	70*c*	3.33	*g*29*c*	2 00
45*c*	2.66	*g*4*c*	3 33		

ates, as respects beauty Of the 23 respondents, those were cast out who deviated farthest from three in the ranking achieved, to find the final 20 The median IQ of the 20 pupils whose photographs compose our control group was 102, according to the group tests given regularly in the school. The median IQ of the graduating class from which they were derived was 108.

It is seen that we obtained a mean quintile ranking of 2 89±0 8 for beauty of the sample used as a control group, in comparison with the total of graduates Our 20 photographs are, therefore, fairly representative of the population desired for purposes of comparison No significant fallacy of selection affects our data, as concerns beauty.

SELECTION OF THE JUDGES

The use of the order-of-merit method and of the method of rating implies an adequate number of independent judges In the appraisal of each of the two series of photographs finally formulated, ten judges participated, making a total of 20 different judges involved. These were graduate students of education and their spouses, clustering between 25 and 35 years of age, except for two professors who were older Each judge appraised *one* series of photographs by *both* methods mentioned Those judging Series I did not judge Series II. Those judging Series II did not judge Series I. Thus in each of the two series of faces studied, not only the faces are different (the control group alone remaining the same), but the judges too are different

Each judge worked in a room alone, except for the presence of the investigator. *There was no consultation among judges.* They worked whenever their leisure happened to coincide with that of the investigator, so that the judging by the 20 judges extended over a period of months. It required, on the average, about two consecutive hours for a judge to complete the judgment of a series of photographs, by both methods

All judges were completely naive as to the real purpose of the experiment. *All were entire strangers to all of those photographed.* None was informed as to the comparative quality or qualities of those represented in the photographs. No information whatever was at the disposal of the judges, except that transmitted in the instructions by which they worked

The Unit of Scrutiny

Even with adult judges, the number of items that can be truly compared each with the others, within one unit of scrutiny, is limited. Since individual order-of-merit comparisons were wanted, preliminary trials were made with two adult judges, using 40 and then all 60 photographs as a unitary task. It appeared that 60 items of this kind were psychologically unwieldy, and that 40 made a much more nearly optimum number, both as objects to judge and as objects to handle.

We therefore divided our 40 photographs of the highly intelligent into two separate series of 20 each. This division into Series I and Series II was accomplished "blindly," as follows.

The 14 girls were placed in a separate pile. Then, all photographs being concealed within their folders, they were made into two piles by dealing left and right, first from the boys, then from the girls This procedure yielded two random series of 20 each, composed each of 13 boys and 7 girls. Each photograph of the total 60 involved was then numbered on the back of its folder with an identification number in cipher.

The unit of scrutiny consisted in all cases of the 20 photographs of the control group mixed alternately with the photographs of a series of the highly intelligent This made 40 photographs in a unit.

The Order-of-Merit Method

The pile of 40 photographs thus formed was placed before the judge by the investigator, with the following typed instructions:

> You will find here 40 photographs of adolescents, from the population of New York City None is younger than 12 and none is older than 25 years of age Please judge them for *good looks* (physical attractiveness) The photographs are to be placed in 5 piles of 8 each. Look them all over. Then place in the first pile the 8 who are least attractive In the second pile place the 8 who are next to the least attractive, and so forth, till the 8 most attractive faces are in the fifth pile. Then take *each pile* of 8, and arrange the faces therein in an order of attractiveness, from least to most When you have finished, Number 1 will be the *least* attractive, and Number 40 will be the *most* attractive face, all faces being in an order of merit for beauty First place the boys Then place the girls. Ask questions about the procedure, if you need to, but there will be no consultation as to the relative beauty of the faces studied

Procedure in Scoring for the Order-of-Merit. When the order of merit had been thus achieved for a given judge, this order was recorded When all ten judges had completed their judgments, the mean and the median of the ten were found respectively for each photograph scrutinized. These central tendencies constitute final values of each photograph, as regards beauty

These values were then distributed, the values for the intelligent and for the controls being kept separate. The median and the mean value for each group was then determined, to constitute the final comparison between intelligent and controls.

When Series I had been completed, the 20 control photographs were mixed alternately with 20 photographs of Series II, and the same procedure was carried out as described for Series I, with ten different judges. Resulting values for all photographs of Series II were found in the same way as for Series I The total results for both Series I and Series II are seen in Table 5

Judgments by the Method of Rating

Procedure When a judge had completed the order-of-merit procedure, and the result had been recorded by the investigator, the

TABLE 5

SHOWING MEANS AND MEDIANS OF TEN COMBINED ORDERS OF MERIT FOR ATTRACTIVENESS, ASSIGNED BY NAIVE JUDGES, TO PHOTOGRAPHS OF HIGHLY INTELLIGENT ADOLESCENTS, AND TO ADOLESCENTS OF ORDINARY INTELLIGENCE

The higher values denote the more attractive faces In each Series, $n=40$

		Series I		Series II	
		Adolescents of IQ 135-190	Adolescents of IQ 90-110	Adolescents of IQ 135-190	Adolescents of IQ 90-110
Values based on medians of the order of merit	Median	22.73	18.48	24.03	16.85
	MV	±8.18	±6.98	±7.08	±7.02
	Mean	24.25	16.50	25.25	14.75
	A.D.	±7.00	±4.75	±6.25	±5.25
Values based on means of, the order of merit	Median	23.15	16.15	23.70	16.25
	M.V	±6.70	±3.55	±3.70	±4.25
	Mean	22.39	18.66	23.84	17.01
	A.D.	±6.87	±5.34	±5.53	±5.17

photographs were "shuffled" into a random order The judge was then presented with a rating scale four inches in length, in five degrees, with typed instructions, as below:

> Please rate each of the 40 photographs accompanying these *instructions upon the following scale* Place *a check mark exactly* at the point you wish to indicate Judgments may fall anywhere, from 1 to 5. Please have in mind as *average* your idea of the average adolescent, as seen in New York City

Very unattractive — Average — Very beautiful

Beauty
1 2 3 4 5

Treatment of Data. It will be seen that the four-inch scale converts itself into a scale from 0 to 16, in terms of quarter inches. By means of a ruler measuring in quarter inches to the points checked on the scale, the ten ratings obtained for each photograph were determined quantitatively. From these two values were assigned to each photograph, (1) the median of the ten ratings, (2) the mean of the ten ratings.

These two values being separately distributed for both groups, the

mean and the median value for each such distribution was found. Table 6 shows these comparative facts. The higher figures indicate comparatively greater beauty

TABLE 6

SHOWING MEANS AND MEDIANS OF TEN COMBINED RATINGS, ASSIGNED BY NAIVE JUDGES, TO PHOTOGRAPHS OF HIGHLY INTELLIGENT ADOLESCENTS, AND TO ADOLESCENTS OF ORDINARY INTELLIGENCE, ON A SCALE FOR BEAUTY OF THE FACE, MEASURING FROM 0-16

The higher ratings denote the more beautiful faces. In both series, the highly intelligent are rated as more beautiful In both Series, $n=40$.

		Series I		Series II	
		Adolescents *of IQ* 135-190	Adolescents *of IQ* 90-110	Adolescents *of IQ* 135-190	Adolescents *of IQ* 90-110
Values	Median	10 00	8 00	8 50	7 50
based on	M V	±2 00	±1 50	±1 00	±1 00
medians	Mean	8 95	7.45	8 90	7 40
of ratings	A D	±2 76	±1 81	±1 64	±1 51
Values	Median	9 60	7 00	8 70	7 30
based on	M V	±1 85	±1 20	±0.90	±1 35
means of	Mean	8.70	7.31	8 99	7 34
ratings	A D	±2 31	±1.67	±1 36	±1 44

INTERPRETATION OF RESULTS

The results of this study are consistently clear-cut, and the interpretation of them is brief and simple. The photographed faces of *highly intelligent adolescents are more attractive (more beautiful)* to adult judges than are those of adolescents who represent the average population of adolescents This is so when the judges are wholly uninformed as to the mentality of any of the photographed persons, and are entirely unacquainted with them. These results apply to adolescents of both sexes

The results hold for judges who are between 25 and 35 years old, *appraising adolescents who are 14 or 15 years old* It would be an interesting extension of our study to present these same photographs to adolescent judges, and to judges 55 to 65 years old, and thus to determine whether the age of judges would affect results.

It is of some value to note here that naive Chinese judges also are more attracted to the faces of the very intelligent than to those of average intelligence, but not to the same extent as in the case of Caucasian judges (6) *The correlation between our Caucasian*

judges and the Chinese judges is .47, both judging Series I of our photographs.

Summary

1. A sample of 40 highly intelligent adolescents of the white race, *selected in childhood on the basis of mental tests* as falling between 135 IQ and 190 IQ (S-B), the selection being originally without regard to personal appearance in any respect, were photographed on plates 8x10 inches Twenty adolescents of the same age and from the same school population, falling between 90 IQ and 110 IQ (by group tests) were photographed in the same way. Both samples were proved to be representative, each of its intellectual group, as regards beauty

2. The highly intelligent, divided into two distinct series, were proved *against the sample of the ordinarily intelligent*, both by the order-of-merit method and by the method of rating

3. The judges chosen were educated adults, 25 to 35 years old, who were total strangers to the adolescents photographed and who had no information in regard to the mentality of any one of them. Each photograph was rated by ten such judges, independently, these judgments yielding a coefficient of reliability of 873 (6)

4 In both series, by both methods, the faces of the highly intelligent were proved to be more attractive (more beautiful) than the faces of members of the ordinary group, all other things being equal

5 *The faces of the highly intelligent maintained their superior* attractiveness, though to a lesser extent, when Chinese (holding age, sex, and education constant) were substituted for Caucasian judges, the correlation between composite Chinese judgments and composite Caucasian judgments being .47 (6)

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LA BEAUTÉ COMPARATIVE DES FIGURES DES ADOLESCENTS TRÈS INTELLIGENTS

(Résumé)

On a photographié des adolescents très intelligents de race blanche, choisis dans l'enfance sur la base des tests mentaux, sans égard de l'attrait physique On a comparé ces photographies à l'égard de la beauté de la figure avec celles des adolescents d'intelligence ordinaire, premièrement selon la méthode de l'ordre de mérite et ensuite selon la méthode d'évaluation Les juges ont été des adultes de race blanche, n'ont eu aucune connaissance avec les jugés, et n'ont pas du tout connu les caractéristiques mentales de ceux-ci Dans deux séries séparées de photographies, les figures des très intelligents, des deux sexes, ont été évaluées comme plus belles que celles des adolescents d'intelligence ordinaire La même tendance a été maintenue quand on a substitué des juges chinois aux juges caucasiens, mais à un degré réduit

HOLLINGWORTH

DIE VERGLEICHENDE SCHÖNHEIT DER GESICHTER VON HÖCHST INTELLIGENTEN JÜNGLINGEN

(Referat)

Höchst intelligente Junglinge der weissen Rasse, die in der Kindheit auf Grund der Intelligenztests ohne Rucksicht auf Korperschonheit gewahlt wurden, wurden photographiert Diese Photographien wurden in bezug auf Schonheit des Gesichts mit jenen der Junglinge mit gewohnlicher Intelligenz verglichen, erstens durch die Methode der Ordnung des Vorzuges und dann durch die Methode der Beurteilung Die Beurteiler waren Erwachsene der weissen Rasse, sie kannten die Beurteilten nicht, und sie wussten nichts von den geistigen Eigenschaften der Beurteilten In zwei getrennten Reihenfolgen von Photographien wurden die Gesichter der hochst intelligenten Junglinge beider Geschlechter als schoner als jene der Junglinge mit gewohnlicher Intelligenz beurteilt. Dieselbe Neigung zeigte sich, wenn kaukasische Beurteiler durch chinesische ersetzt wurden, obgleich zu einem kleineren Grade

HOLLINGWORTH

A MULTIPLE FACTOR ANALYSIS OF CHILDREN'S ANNOYANCES*[1]

From the Institute of Child Welfare, University of California

HAROLD D CARTER, HERBERT S. CONRAD, AND MARY COVER JONES

I. INTRODUCTION

The present study applies the Thurstone multiple factor technique (3, 4) to data from an "annoyance inventory." Results from three factor analyses will be presented In the *first* analysis, it is shown that the intercorrelations between different classes of annoyance items may be considered as arising largely from the operation of three independent "factors" The *second* factor analysis is confirmatory of the first. The *third* factor analysis traces the effect of introducing intelligence test score as a variable in the table of intercorrelations among annoyances, this is of some interest for factor theory, and in addition it leads to conclusions which were neither observed nor readily observable from the original, unfactored data.

II. THE SAMPLE

The present report is based on a sample of 100 children (50 boys and 50 girls), tested both in 1933 and 1934 These children constitute a subgroup of the larger sample used by the Institute of Child Welfare in its studies of adolescence; the subgroup was selected on the basis of its availability for an intensive, cumulative program of measurement. At the time of the *first* testing with the Annoyance Inventory, about half the children were in the high-sixth grade of five elementary schools, and half in the low-seventh grade of a junior high school, in Oakland, California

III. THE DATA

The Annoyance Inventory forming the basis of the present study was devised by M. Gross, H. E. Jones, and M. C. Jones, for use

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[1]A study of children's annoyances, of which this is a part, was initiated in 1933 at the Institute of Child Welfare by Harold E Jones Acknowledgment is given to the earlier work of Hulsey Cason (2) in this general field.

with children between the ages of ten and 16. The Inventory consists of items which are considered more or less representative of annoyance stimuli experienced by, or known to, adolescents. Form A of the Inventory consists of 105 items; Form B, of 140 items (of these, 96 occur also in Form A) Both Forms A and B were administered in the spring of 1933, and again in the spring of 1934; in each year, Form B was given a week after Form A. On each occasion, the Inventory was administered as a group test in the children's classrooms, by M. C Jones

Table 1 presents samples of the items in the Inventory, and indicates briefly the nature of the 11 classes or categories into which the

TABLE 1

SAMPLE ITEMS FROM THE VARIOUS CLASSES OF THE ANNOYANCE INVENTORY

Class 1 Sound
A dog barking at night
Hearing static or similar noises on the radio.
Class 2 Sound (Personal)
Someone practicing singing exercises
Someone who whistles loudly in the house
Class 3. Untidiness (Dirt)
Seeing a wash-bowl with a ring of dirt on it.
Furniture with dust on it
Class 4 Untidiness (Lack of neatness)
Seeing a desk all cluttered up with papers
Seeing a *picture that isn't hung straight on a wall.*
Class 5 Untidiness (Personal)
A child whose face is dirty or grimy.
Seeing someone whose hair is all mussed up
Class 6 Impropriety in eating
Someone trying to talk while he has too much food in his mouth
Someone who soaks his bread or cake in his coffee or tea.
Class 7 Bad form
Someone who *is a poor loser in a game*
A boy or girl who is rude to a much older person.
Class 8. Infringement
To have someone walk in front of my seat at the movies.
Having to get off the sidewalk to pass some people who are taking up all the room
Class 9 Injury to self-esteem
To have a hole in my stocking where it shows
Someone who does *not pay attention to what I am saying.*
Class 10 Miscellaneous (Personal)
Someone with a bad breath.
To answer the door and find it is only a salesman
Class 11 Miscellaneous
Walking on sugar which has been spilled on the floor
The smell of garbage

items have been grouped The selection of the 11 categories of classification, and the placement of items within each category, were carried out through the consensus of opinion of four psychologists The items belonging to any given class were scattered at random throughout the entire Inventory. Table 2 shows the number of

TABLE 2

THIS TABLE SHOWS THE NUMBER OF ITEMS IN EACH CLASS OR CATEGORY OF THE ANNOYANCE INVENTORY, * AND THE TOTAL NUMBER OF ITEM-RESPONSES ON WHICH A CHILD'S SCORE IS BASED

Class	Number of items Form A	Form B	Total no of responses (1933+1934)
1. S (Sound)	17	18	70
2 SP (Sound-Personal)	17	22	78
3 UD (Untidiness-Dirt)	13	13	52
4. UN (Untidiness-Neatness)	10	9	38
5 UP (Untidiness-Personal)	17	17	68
6. IE (Impropriety in eating)	8	10	36
7. B (Bad form)	7	14	42
8 I (Infringement)	4	9	26
9 SE (Injury to self-esteem)	5	14	38
10 MP (Misc-Personal)	4	9	26
11 M (Miscellaneous)	3	5	16
Total Inventory	105	140	490

*For administration in the spring of 1935 and subsequently, an enlarged 160-item Inventory has been prepared, with additions especially in the classes I and SE

items in each class, for Form A and Form B separately. Since there are 105 items in Form A, and 140 in Form B, and both forms were taken twice, a child's score on the total Inventory is based on a total of 490 item-responses at four different administrations. The response to each item of the Inventory consists in the encircling of either an "M," an "L," or an "O"—according as the particular item is reported as provoking much, little, or no annoyance, respectively. In scoring the subject's responses, the encircling of an "M" is counted as 2, of an "L" as 1, and of an "O" as zero. The subject's raw score on the total Inventory is simply the total of his scores on all the separate items, similarly, the subject's score for any class or category is simply the total of his scores on the items in that particular category. In the present study, the data from all four admin-

istrations of the Inventory have been combined,[2] in order to eliminate transient influences, and to secure the greatest possible reliability of measurement.

The technique of combining scores from the four testings requires a word of explanation For each child, the raw scores from the four testings were added, the resulting distribution was then normalized, and original scores converted to scale scores (similar to T-scores), with a mean at 50 and a standard deviation of 10 This procedure was followed for the score on the total Inventory, and also for the score on each of the eleven classes or categories of the Inventory. The normalization is easily justifiable, since the distributions of raw summed scores were approximately normal The purpose of normalization and conversion to scale scores was to provide scores of uniform meaning, useful for inspectional comparison with data from other group tests and measurements similarly treated

IV Reliability of the Measurements

The "split-half" reliability of the Inventory was obtained by dividing the Inventory into two equivalent halves, and calculating the correlation between the raw scores on the two halves. The items of the two halves were paired on the basis of *a priori* qualitative similarity, and on the basis of the empirical data concerning the provocativeness of each item. The Spearman-Brown reliability coefficient for the total Inventory (four administrations) is 990, the reliability coefficients for the eleven classes of the Inventory (as listed in the last column of Table 4) are generally .90 or above

The retest (as opposed to split-half) reliability of the Inventory has not been computed for the sample of the present study In a larger unselected group, of which the present group is a part, the correlation between weekly retests (Form A vs Form B) is around 85 for the entire Inventory, and around 75 for the individual categories

The correlation between age and scores on the Annoyance Inventory is uniformly very close to zero in our sample, hence none of the reliability coefficients mentioned above is affected by a spurious age-factor

[2]This procedure is justified in view of the similarity of the two forms, and the high agreement of results secured in the different testings

In addition to Annoyance Inventory scores, the present study makes use of the children's intelligence quotient The intelligence quotient is based upon four intelligence tests; viz., the Thorndike CAVD, the Terman Group Test, the Kuhlmann-Anderson, and the Stanford-Binet (short scale only) The reliability coefficient for the measure of intelligence based upon all these tests is estimated as about .97 (two of the tests have reliability coefficients of .95 each).

V. Intercorrelations

Table 3 shows the intercorrelations between 13 variables: intelligence quotient, total annoyance score, and annoyance scores for each of the eleven classes of the Annoyance Inventory. From inspection of the table, it appears that *each* of the annoyance scores is somewhat negatively correlated with intelligence (median, about —.20). The scores for each of the 11 individual classes of the Annoyance Inventory are highly correlated with total Annoyance Inventory score (generally over .85). The intercorrelations among the 11 annoyance categories are also fairly high, ranging from 57 (between *infringement* and *untidiness-personal*) to .93 (between *untidiness-personal* and *untidiness-dirt*). Since the reliability coefficients for the individual categories are practically all over .90, it is clear that, while the 11 classes apparently have much in common, the intercorrelations cannot be explained entirely on the basis of a single common factor Certain pairs of categories are a good deal more closely correlated than others; and this variation is not determined by differences in reliability of the scores for the various classes. Thus, the two *sound* categories correlate .86 with each other, but around 70 with other (equally reliable) categories. Similarly, the three *untidiness* classes (*UD*, *UN*, and *UP*) are intercorrelated to the extent of .90 or over, but correlate only around .60 with *infringement*

Careful examination of the table of correlations indicates a conspicuous "cluster" of the three *untidiness* classes (inter-r's 90 or over). Associated with the response to *untidiness* are the responses to items classified as *impropriety in eating* and *bad form* (the inter-r's between these and the *untidiness* classes are over 80) The classes *I*, *SE*, and *MP* (*infringement, injury to self-esteem*, and *miscellaneous-personal*) constitute a highly in-

TABLE 3

INTERCORRELATIONS AMONG INTELLIGENCE, TOTAL ANNOYANCE INVENTORY SCORES, AND SCORES ON INDIVIDUAL CLASSES OF THE ANNOYANCE INVENTORY (N=100).

Variable	IQ	T	1 S	2 SP	3 UD	4 UN	5 UP	6 IE	7 B	8 I	9 SE	10 MP	11 M
Intelligence		—.23	—06	—20	—26	—.29	—25	—26	—15	—04	—20	—13	—13
Total Annoyance score	—23		80	87	92	90	.89	94	.90	78	87	87	.88
1. S (Sound)	—06	80		86	66	62	59	60	.65	72	71	72	75
2 SP (Sound-Personal)	—20	87	86		73	72	69	72	72	73	74	.79	79
3 UD (Untidiness-Dirt)	—26	92	.66	73		91	93	84	83	64	76	73	85
4 UN (Untidiness-Neatness)	—.29	.90	62	72	91		.90	83	81	61	74	74	78
5 UP (Untidiness-Personal)	—25	89	59	69	93	90		85	.82	57	74	71	77
6 IE (Impropriety in eating)	—26	94	60	72	84	83	85		.81	61	72	72	76
7 B (Bad form)	—15	.90	65	72	83	81	82	81	.	75	85	84	80
8 I (Infringement)	—04	.78	72	73	64	61	57	61	75		82	85	76
9. SE (Injury to self-esteem)	—20	87	71	74	76	74	74	.72	85	82		89	.77
10 MP (Misc.-Personal)	—13	87	72	.79	73	74	.71	72	.84	85	.89		79
11 M (Miscellaneous)	—13	88	.75	79	85	78	.77	76	80	76	.77	79	

tercorrelated trio (around 85), as do also the classes *B*, *SF*, and *MP* (*bad form*, *injury to self-esteem*, and *miscellaneous-personal*—average, over 85) The class *sound* (except for its high relation to *sound-personal*) is the most nearly independent of all the classes of the Inventory The class *I*, *infringement*, also appears to lay some claim to comparative independence In the next section we shall observe to what extent a factor analysis by the Thurstone center-of-gravity technique bears out the groupings indicated above

VI The First Factor Analysis

In the present paper, three factor analyses will be presented. The first factor analysis involves the intercorrelations between scores in the 11 classes of the Annoyance Inventory (cf Table 3) By the first analysis, four group factors have been extracted. The "factor loadings"—i e., the correlations between each factor and the original annoyance categories—are given in Table 4 As shown in Table 4,

TABLE 4
QUANTITATIVE RESULTS OF THE FIRST FACTOR ANALYSIS
(Based on intercorrelations among 11 classes of the Annoyance Inventory)

	Class	Loading for the four factors *I*	*II*	*III*	*IV*	Sum of squares	Reliability coefficient
1	S (Sound)	80	—33	—27	03	82	.96
2	SP (Sound-Personal)	87	—23	—28	16	91	92
3	UD (Untidiness-Dirt)	91	.29	—11	—.12	94	95
4.	UN (Untidiness-Neatness)	89	31	—04	03	89	94
5.	UP (Untidiness-Personal)	88	.39	—04	05	93	96
6	IE (Impropriety in eating)	86	26	—01	05	81	93
7	B (Bad form)	.91	08	20	00	87	94
8	I (Infringement)	82	—35	19	—12	.85	89
9	SE (Injury to self-esteem)	90	—14	25	05	.89	90
10.	MP (Misc.-Personal)	90	—22	22	.08	91	90
11	M (Miscellaneous)	90	—04	—09	—19	86	84
	Mean*	88	.24	.15	08	88	92

*The mean factor loading is taken without regard for sign

the value of the average sum of squares of the factor loadings is not far below the average reliability coefficient, indicating that the four factors serve to account for the correlations of Table 3 fairly well

Factor analysis indicates *how many* independent group factors are

required in order to account for the intercorrelations among a set of variables, it does not directly indicate the *nature* of these factors. From the point of view of factor analysis, each factor is merely itself, i e., each factor is completely defined by its statistical derivation. To discover the nature of a factor, in terms of other known variables, it is necessary to have the correlations of the factor with these other variables. Such correlations, or "factor loadings," are given in Table 4, and are more conveniently presented in Table 5.

TABLE 5

THE CLASSES OF THE ANNOYANCE INVENTORY WITH COMPARATIVELY LARGE POSITIVE FACTOR LOADINGS, AND WITH COMPARATIVELY LARGE NEGATIVE FACTOR LOADINGS, RESPECTIVELY

(First factor-analysis)

Positive loadings Class	Loading	Negative loadings Class	Loading
Factor I			
All classes have high positive loadings with Factor I (average, 88)			
Factor II			
UP	39	I	—35
UN	31	S	—.33
UD	29	SP	—23
IE	26	MP	—22
Factor III			
SE	25	SP	—.28
MP	.22	S	—27
B	20		
I	19		
Factor IV			
SP	16	M	—19

From Table 5, it appears that the first factor—heavily loaded with all classes of the Annoyance Inventory—may best be thought of as *general annoyability* This is by far the largest of the four factors.[8] The second factor is most heavily loaded (positively) with the

[8] *To the extent that the intercorrelations in Table 3 are affected by correlated* response-errors at each administration of the Inventory, the inter-r's in Table 3 are spuriously high, and the general annoyability factor is too large *That the general annoyability factor is not due merely to the correlation* of response-errors is indicated by the differences between intercorrelations and reliability coefficients, and by the considerable differences in the *correlation between certain pairs of classes in Table 3. Other evidence, not* included in the present paper, is the wide and appropriate variation in provocativeness of the individual items of the Annoyance Inventory

classes *UP*, *UN*, *UD*, and *IE*, this may be characterized as an "untidiness" factor The third factor is positively related to certain personal annoyances, such as are included in classes *SE*, *MP*, *B*, and *I*, this factor is hard to name concisely—"susceptibility to personal annoyances" and "introversion" are not sufficiently restrictive, and no other useful phrase suggests itself The fourth factor is of least importance in determining the intercorrelations between the annoyance classes; and since two later factor analyses confirm the impression that this fourth factor is comparatively narrow, specific, and unstable, we shall dismiss it without further consideration

The negative factor loadings of Table 5 are just as interesting as the positive Sizeable negative loading of the second factor is found in classes *I*, *S*, *SP*, and *MP* (*infringement*, *sound*, *sound-personal*, and *miscellaneous-personal*), sizeable negative loadings of the third factor are found in classes *SP* and *S* (*sound-personal* and *sound*). Evidently, a person scoring high in the second factor will be more likely to be annoyed by untidiness than by items in classes *I*, *S*, *SP*, or *MP*, a person scoring high in the third factor will be more likely to be annoyed by items in classes *SE*, *MP*, *B*, and *I*, than by items in classes *S* or *SP*. This ***contrast nature*** of the factors is an interesting and distinctive contribution of factor analysis.

The continuum implied in the first factor—much annoyability vs little annoyability—is obvious and easily grasped; it is of the sort implied by the assumptions of quantitative measurement. But the continua implied in the other factors are empirical discoveries; like the correlations between different tests, they cannot be predicted *a priori*. The method of arriving at them is scientifically objective, and they necessarily reflect trends present in the data They imply that a component of one group of variables is opposed to a component of another group of variables; or, applying the rule of parsimony, the same component is positively included in one set of variables and negatively included in another As a hypothetical case, consider intelligence as a component of the second factor. Since it is intelligent to be greatly annoyed by infringements upon one's rights, and comparatively less intelligent to be greatly annoyed by untidiness (an empirical finding, quantitatively presented in the next section), there is a component (intelligence) leading these two groups of annoyances to be opposed. This ***opposition*** is not clearly evident in the original variables, because *other components of heavier weight* are

in *agreement* throughout all the variables—as evidenced by the high correlations between the various annoyance classes. Persons acquainted with test results know in general that total score on a test does not adequately present all the results of measurement. Such workers usually note tendencies of individuals to score high on some material and comparatively low on other material, and they cite this fact as the sort of evidence ignored in total score When such tendencies are present, and characteristic of groups of persons, a factor analysis will summarize these tendencies, and indicate them in order of importance

Table 5 indicates that as one moves from high to low scores in Factor II, there is a continuous decline in annoyance at *untidiness* and a steady increase in response to annoyances *I*, *S*, *SP*, and *MP*. A high score in Factor II, then, implies not only great annoyance at *I*, *S*, *SP*, and *MP*, but also little annoyance at *untidiness*. In short, scores in Factor II are in the nature of *difference* scores between *I*, *S*, *SP*, and *MP* on the one hand, and *untidiness* on the other From the original classification of items (Table 1) and the table of intercorrelations (Table 3), it is not immediately evident that a continuum of the sort indicated by Factor II exists Extraction of the factor loadings amounts to the *discovery* that such a continuum exists Similar considerations of course apply to Factor III also

VII. The Second Factor Analysis

The second factor analysis is identical with the first, except that the score on the total Annoyance Inventory has been included as a variable in the table of intercorrelations. On theoretical grounds one would expect that the results of this factor analysis should (at least for the major factors) run parallel to the results of the first analysis Inspection of Table 6 shows that this expectation is strikingly confirmed. The loadings for Factors I, II, and III of the first factor analysis are practically identical with those for Factors I, II, and III of the second factor analysis (cf. Table 6, column 2 vs 3, 5 vs. 6, and 8 vs. 9). Evidently, the change of "set-up" in the table of intercorrelations (through addition of total Inventory score) has had practically no effect on Factor I, nor—despite their comparatively small magnitude—on Factors II and III

TABLE 6

THE LOADINGS FOR EACH FACTOR, AS FOUND IN THE FIRST,* THE SECOND,† AND THE THIRD‡ FACTOR ANALYSES

Variable	Factor I Analysis No			Factor II Analysis No			Factor III Analysis No.			Factor IV Analysis No		
	1	2	3	1	2	3	1	2	3	1	2	3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Intelligence	-		—23	·		30			01			33
Total Inventory		99			09			—05	·	..	13	·
1. S	80	80	.79	—33	—32	31	—.27	—31	34	.03	03	—05
2 SP	87	.87	87	—.23	—.23	20	—28	—.24	24	16	14	—16
3 UD	.91	.91	92	29	27	—.26	—11	—10	.09	—12	—18	13
4 UN	89	.89	90	31	29	—30	—.04	—03	00	03	—02	02
5 UP	88	88	89	39	37	—34	—04	—01	—01	.05	—05	.13
6 IE	.86	88	87	.26	28	—22	—01	—03	—03	05	.26	03
7 B	.91	91	.90	08	.07	02	20	19	—19	00	—02	17
8. I	82	82	81	—35	—35	.40	19	16	—11	—12	—04	06
9 SE	90	89	.90	—.14	—15	18	.25	23	—24	05	—06	—07
10 MP	90	90	.89	—22	—.23	.27	22	.24	—22	.08	03	—01
11 M	90	90	89	—04	—05	08	—09	—12	15	—19	—10	15
Mean§	88	88	88	24	24	.23	.15	15	15	.08	08	09

*Based on the intercorrelations among the 11 annoyance inventory classes

†Identical with the first factor analysis, except that the score on the total Annoyance Inventory has been included as a variable in the table of intercorrelations

‡Identical with the first factor analysis, except that an intelligence score (IQ) has been included as a variable in the table of intercorrelations

§The mean factor loading is taken without regard for sign To facilitate comparison, the mean of each column always represents the mean loading for the eleven classes of the Annoyance Inventory.

VIII The Third Factor Analysis

The third factor analysis is identical with the first, except that the variable "intelligence" has been introduced in the table of correlations The purpose of including intelligence is twofold: first, to observe the relation of intelligence to annoyance factors, and second, to observe the effect, upon factor loadings, of introducing a variable which is greatly different from the others in the table of intercorrelations

Table 6 gives the quantitative results of the third factor analysis It is clear, from this table, that very close agreement exists between the first, second, and third factor analyses, with respect to Factors I, II, and III,[4] in all three analyses, the loadings for a given factor are quite similar. Factor IV, however, is evidently different in each analysis This factor—the smallest and least influential one—is evidently strictly dependent on the peculiarities of the particular intercorrelational "set-up" The first three factors, on the other hand, remain stable when another variable is added to the table of intercorrelations The writers have, on several occasions, heard the criticism that the results of factor analysis are strictly dependent upon the intercorrelational "set-up" The implication of this remark has generally been that factor analysis leads to results which are comparatively fragile, delicate, undependable The results from our three factor analyses, as well as from certain previous work (1), appear rather definitely to discredit this idea, and to lay the burden of proof on the critics.

One interesting finding deserves some comment. In Table 3 (the table of intercorrelations), it appears that intelligence is *negatively* related to total Annoyance Inventory score, and also to the score in each class of the Inventory In Table 6, however, it appears that intelligence is *positively* loaded with Factors II and IV (of the third analysis). Evidently, then, whatever is measured by Factors II and IV (of the third factor analysis) is *positively related to intelligence* We do not care to stress this result for Factor IV, since (as we have shown above) there is question concerning the general significance

[4] The loadings for Factors II and III of the third analysis differ in algebraic sign, but not essentially in magnitude This is as if one replaced a variable like "boldness" by one termed "timidity" The two differ (so to speak) in algebraic sign, but represent the same variable

of this factor Factor II, however, is stable, and the results for this factor may be taken seriously High scores in Factor II of the third analysis, it will be recalled, indicate annoyance at *infringement*;[5] low scores indicate annoyance at *untidiness*. In strictest theory, all we may say is that Factor II is positively related to intelligence There is a strong temptation to add, however, that intelligence is positively related to the tendency to report annoyance at *infringement* (*as measured by Factor II*) and negatively related to the tendency to respond to the items in *untidiness* (*as measured by Factor II*) Among children of a given level of general annoyability (i e, of a given score in Factor I), the more intelligent are more strongly responsive to the positive end of Factor II than the negative. Other things being equal, intelligent children are characterized by greater annoyance at *infringement* than at *untidiness*. Here is a finding which appears rational and "sensible", and which is much more clearly revealed by factor analysis than by the slight variation in negative correlations of intelligence with the original scores.

IX Interpretation

We wish to recognize, here, certain limitations of the present investigation. An important consideration is the fact that the results are based on the self-report of young adolescent children. There undoubtedly is an age below which the method of self-report should not be used; the statistical evidence of validity of the method in the present sample consists in the findings concerning reliability (section IV), the distinctions among the annoyance-classes (Tables 3-6), and the variation in provocativeness of the individual items of the Inventory (footnote 3) [6]

We have already discussed the "meaning" of the factors, in the section dealing with the first factor analysis. The factors are mathematical entities, determined and defined by mathematical procedure—just as the mean is determined and defined by $\frac{\Sigma X}{N}$, and the

[5]Also *sound* and *miscellaneous-personal*, but rather more especially *infringement*.

[6]It would, of course, be desirable to supplement the method of self-report by more objective and experimental techniques For certain selected annoyances adaptable to such techniques, an instrumental study has been undertaken by other members of the Institute of Child Welfare.

coefficient of correlation is determined by the formula $\frac{\Sigma xy}{N\sigma_x\sigma_y}$ These latter mathematical concepts have acquired practical meaning through use The same may be said of factors. One obvious use to be made of factors is to find the correlations between the factors and other variables (including other factors). Such correlational studies, extensively conducted, are capable of establishing the "meaning" or psychological significance of factors on a sound empirical basis.

Factors are derived from tables of intercorrelations—do they tell us anything not discernible from the intercorrelations themselves, or not obtainable by strictly correlational techniques? The answer is indicated in Tables 4-6 These tables list a ***small number*** of ***independent*** "factors," capable of explaining the intercorrelations among many non-independent variables. These factors are new entities, sometimes exhibiting characteristics not openly shown by any of the originally measured variables Moreover, the contrast nature of many of the factors reveals trends which are hardly obvious from the *table of intercorrelations alone* [7]

It is quite evident that there are other valid approaches to the analysis of our data from the Annoyance Inventory. Correlation and factor analysis both seem to leave much to be desired, for example, from the point of view of clinical interpretation The new approach *of factor analysis, however, merits our consideration as one of many* possible avenues which must be explored in the search for adequate methods of measuring personality traits.

X. Summary and Conclusions

An Inventory of common annoyances was devised, and was administered on four different occasions to each of 100 school children

[7]Question may arise in the minds of some readers whether an equally efficient analysis of the original data could not have been contrived through the extensive use of partial correlation. This is not the place to indulge in any lengthy comparison between the two techniques of partial correlation and factor analysis It is well to note here, however, that factor analysis most "parsimoniously" *replaces* the original variables by independent "factors", and that the factors after the first are in the nature of difference scores. Thus, our second factor may be thought of as indicating the *difference* between annoyance at infringement and annoyance at untidiness (cf section VI, on the "contrast nature" of the factors). It is difficult to see how partial correlation could, with equal elegance or economy, achieve the results of factor analysis.

For purposes of the present investigation, scores from the four administrations have been combined, in order to eliminate the effects of transient conditions, and to secure high reliability of measurement.

The items of the Inventory were classified into 11 different groups, and a score obtained for each of these classes (as well as for the total Inventory). Intercorrelations between the scores in the various classes were computed, and three multiple factor analyses of the intercorrelations, by Thurstone's simplified method, have been carried out, with conditions somewhat altered in each analysis. The findings support the following conclusions:

1. Four factors serve fairly well to account for the intercorrelations among the various classes of the Annoyance Inventory.

2. The Annoyance Inventory has provided stable measurement of the first three factors. When the intercorrelational "set-up" was changed by the addition of another variable, the first three factors remained the same, but the fourth factor was disrupted.

3. The first factor, which is by far the largest, measures general annoyability (within the limitations of the present Inventory). Factors II and III are less easily described. Factor II is comparatively heavily loaded (positively) with the *untidiness* classes of the Inventory, and loaded (negatively) with the *infringement*, *sound*, *sound-personal*, and *miscellaneous-personal* classes of the Inventory. Factor III is comparatively heavily loaded (positively) with a group of personal annoyances—*injury to self-esteem*, *bad form*, *infringement*, and *miscellaneous-personal*; and negatively with *sound* and *sound-personal*.

4. The scores for the total Annoyance Inventory, and for each class of the Inventory, correlate negatively with intelligence, the correlations ranging from —.04 to —.29. The correlations with intelligence are —.23 for Factor I, +.30 for Factor II, and +.01 for Factor III. Thus the factors reveal differentiable trends of annoyance in relation to intelligence, much more clearly than the slight variation in negative correlations of intelligence with the original scores.

5. The comparative procedures applied here have provided proof of the stability of the annoyance factors, evidence concerning their meaning, and knowledge of their relation to intelligence. Methodologically, it is clear that a single factor analysis is not likely to be any more fruitful than a single, isolated average or coefficient of

correlation. What is required are numerous analyses, under systematically varying conditions—the marriage of statistics and experimentation.

NOTE. Since this article was written, Dr. L. L. Thurstone has published his book *The Vectors of Mind*. This more comprehensive formulation of factor theory includes the description of further techniques, not applied to the data in this article. These further techniques for rotating the axes and securing a unique "simple structure" are intended to throw additional light upon the nature of the components. However, the method involves maximizing the number of zero entries in the factorial matrix. In view of the uniformly high positive loadings of Factor I (See Table 6) resulting from the high intercorrelations among the original annoyance classes (See Table 3), we are at present in some doubt as to the applicability of the new techniques to the present data.

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L'ANALYSE DES FACTEURS MULTIPLES DES ENNUIS DES ENFANT

(Resumé)

On a formulé un inventaire des ennuis ordinaires, et l'a fait subir à chacun de 100 élèves à quatre occasions différentes. On a classifié les points de l'inventaire en onze groupes divers. On a computé les intercorrélations entre les résultats dans les diverses classes, et l'on a fait trois analyses des facteurs multiples des intercorrélations, selon la méthode simplifiée de Thurstone, avec les conditions un peu changées dans chaque analyse. Les données soutiennent les conclusions suivantes.

1. Quatre facteurs servent assez bien pour expliquer les intercorrélations entre les diverses classes.

2. Une corrélation négative (de —0,04 à —0,29) existe entre l'intelli-

gence et les résultats bruts dans les diverses classes de l'inventaire des ennuis. En contraste, la corrélation entre l'intelligence et le Facteur II est de +0,30, les corrélations entre l'intelligence et les Facteurs I et II sont de —0,23 et +0,01, respectivement. Ainsi les facteurs montrent des tendances d'ennui qu'on peut différencier à l'égard de l'intelligence, beaucoup plus clairement que la petite variation dans les corrélations négatives de l'intelligence avec les résultats originaux.

3. L'inventaire des ennuis fournit une mesure stable des trois premiers facteurs. Quand on a changé le "groupement" des intercorrélations par l'addition d'une autre variable, les trois premiers facteurs sont restés les mêmes, mais le quatrième facteur (numériquement le plus petit) a été brisé.

CARTER, CONRAD, ET JONES

EINE VIELFACHE FAKTORENANALYSE DER VERDRÜSSE VON KINDERN

(Referat)

Ein Inventar der gewöhnlichen Verdrüsse wurde aufgestellt und jedem von 100 Schulkindern vier verschiedene Male gegeben. Die Einzelheiten des Inventars wurden in elf verschiedene Gruppen eingeteilt. Die Zwischenkorrelationen zwischen den Werten in den verschiedenen Klassen wurden ausgerechnet. Drei vielfache Faktorenanalysen der Zwischenkorrelationen wurden vermittelst der Thurstone vereinfachten Methode ausgeführt, indem die Bedingungen bei jeder Analyse verändert wurden. Die Befunde unterstützen die folgenden Schlüsse:

1. Vier Faktoren dienen ziemlich gut zur Erklärung der Zwischenkorrelationen unter den verschiedenen Klassen.

2. Eine negative Korrelation (von —0,04 bis —0,29) besteht zwischen Intelligenz und den groben Werten in den verschiedenen Klassen des Verdrussinventars. Im Gegensatz dazu ist die Korrelation zwischen Intelligenz und Faktor II + 0,30, die Korrelationen zwischen Intelligenz und Faktoren I und II sind —0,23 bzw. +0,01. Dadurch zeigen die Faktoren unterscheidbare Neigungen des Verdrusses im Verhältnis zur Intelligenz klarer als die geringe Variation in den negativen Korrelationen der Intelligenz mit den ursprünglichen Werten.

3. Das Verdrussinventar verschafft beständige Messung der ersten drei Faktoren. Wenn die Aufstellung der Zwischenkorrelationen durch die Beifügung einer anderen Variable verändert wurde, bleiben die ersten drei Faktoren dieselben, aber der vierte Faktor (der Zahl nach der kleinste) wurde auseinandergerissen.

CARTER, CONRAD, UND JONES

THE RELATIVE DIFFICULTY OF MECHANICALLY EQUIVALENT TASKS. I HUMAN LEARNING*

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DONALD SNYGG

Theories of learning fall, in general, into one of two quite dissimilar groups: objective theories, which ignore any relationship between the learner's achievement and the way he is experiencing the tasks, and phenomenological theories, which attribute the increased efficiency of performance to changes in the way the task is experienced. Theories of the first type commonly make use of the expression "trial and error"; theories of the second type emphasize "insight," "understanding," or "means-ends relations." These disparate views represent two ways of studying learning, either wholly in terms of objective performance of the learner, or with additional data regarding the learner's experience of the task. The latter experiential approach need not be purely introspective as reported by the learner himself. It can also be approached in terms of inferences to be drawn by an onlooker from certain aspects of a learner's performance.

Traditionally the study of learning thus involves the description of successive performances of the same task by an individual who participates in the learning or who merely looks on. The description is dependent upon which rôle the reporter is playing. Objectively, that is as viewed by an outside observer, the problem to be learned remains unchanged while the objective activities of the learner change in speed or distance on successive presentations. As experienced by the learner, however, it is the task which changes, the learner remaining unchanged.

The advantages of the objective method are threefold: the activity of the learner may be viewed by more than one observer, it may be measured in units of time and distance; and these measurements may be correlated with other observable and quantifiable con-

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ditions such as number of presentations or time of practice, amount of reward, or strength of obstacle, data which the learner cannot share until he ceases to be a learner and becomes an observer.

While these advantages are universally admitted there is some question as to the adequacy of the data which it is possible to secure by the use of objective methods alone. It might be said that their present inadequacy for predictions of behavior is tacitly admitted in an inability to formulate objective theories without making inferences of physiological changes in the learner. Since the outside observer, as we have pointed out, experiences the problem as unchanging, it seems inevitable that the unobserved conditions of learning shall then be assigned to other grounds, in this case the learner. Having approached the study of learning from the viewpoint of the learner and noted the way in which the task is experienced as changing during the course of learning, Kohler (2) was led to infer that the increase in efficiency of his animal subjects went hand in hand with the way in which they experienced their tasks. In either case the observer is driven to inference.

The data furnished by the introspections of the learner are unsatisfactory, in that the experience cannot be directly shared by others, with the result that the formulation of quantitative laws is impossible. And similarly data furnished by the objective technique may be unsatisfactory through assuming to be complete while ignoring experiential variables. The ease with which present objective methods may investigate concommitant variations of speed of performance, amount of practice, number of repetitions, strength of obstacle, or amount of reward or punishment etc., had encouraged the study of these relationships only. The possibility of relating two quantitative variables has led us to concentrate on the quantitative aspects of behavior in the hope of reducing the character of the covariation to mathematical formulae. And the faith that this will one day be possible has led behaviorists in particular to reject data which could not in this fashion be quantitatively expressed.

The problem attacked in the investigation reported below is "Why is one task more difficult to perform or to learn than another?" To this question an intelligent child might give two answers: "Because there is less work to do." That is, the mechanical obstacles are less, and "Because I know it better." While both answers are

those of a learner rather than of an observer, both name determinants of difficulty for which objective criteria are available. In the first case it is possible to describe the activity required for performance in units of mass moved and distance traversed; in the second, it is possible to assume that units of practice or repetition are criteria of familiarity. But the child may also give another answer: "This is less difficult because it is simpler." This answer, though apparently plain, is apt to prove otherwise when one attempts to find quantitative criteria of simplicity. For this reason exponents of the objective approach have tended to reject the validity of "simplicity" and its more sophisticated relatives "belonging" and "Gestalt" on the plea that the first two answers are sufficient, that difficulty may be fully predicted in terms of length of task and amount of practice. If this be questioned it would be the duty of the questioners to prove the inadequacy of those factors, since we should not be expected to relinquish quantitative methods for qualitative ones without very good reason. On the other hand, should the questioners demonstrate that the mechanical factors and amount of practice are inadequate to explain difficulty, the objectivist cannot salvage his quantitative system by drawing inferences in terms of "habit" or "instinct," etc., since these are not open to measurement.

From this point of view the crucial question for investigation becomes "May two tasks requiring the same or mechanically equivalent motor responses differ in time required for performance?" If they do not differ in speed of performance the phenomenological approach is superfluous and unnecessary; if they do differ, what laws best describe and predict such differences in difficulty? For instance, it is easier to cancel the letters d r i n k from a paragraph of pied letters than to cancel the letters r d n k i from the same paragraph. Mechanically the two tasks are identical but unless they are recognized as identical they will be performed at very different rates. It thus appears that the factors determining performance time are not merely "mechanical" and it is this "something other" that we propose to investigate.

It is quite possible to make at least some of these "other" conditions observable and objective by studying the performance by the same individuals, or by comparable groups, of tasks which are mechanically equivalent. Under such circumstances any difference in

performance time may be compared with the other objective differences between the tasks It is upon this general method, the comparison of performance times of mechanically equivalent tasks, that the experiments in this investigation were based. Since the method was not fully developed prior to the experimentation, but grew out of the exigencies of the search, the earlier experiments fall short of the ideal form In the final experiment on human subjects it was possible, by selecting suitable tasks and using each subject as his own control, to equate the tasks for motivation, maturation, and previous experience as well as for motor response

The first section of the present study is the description of an effort to make the so-called "subjective" conditions of difficulty observable inferentially to the experimenter These conditions might then be systematically varied and the results of such variation used as data for the formulation of principles adequate for prediction The second section, to be presented in a later paper, is an account of a series of experiments in which the principles derived from the work on human subjects were applied in predicting the comparative number of trials required by white rats for the mastery of various maze problems

In the introduction we have classified the determinants of performance times as. (1) mechanical, the gross physical features of the activity in terms of mass and distance, and (2) "something other," the unknown factor which we intend to investigate Since the "mechanical" features include most of the objective data ordinarily discernible by an outside observer, it is impossible for that observer to proceed further alone without abandoning observation and drawing inferences of "practice," "repetition," or "synaptic conductivity" as explanations of difference in performance times There is, however, another observer in the situation, namely the subject; and while it is impossible to compare change in his experience of the tasks with changes in their performance times with any degree of precision, it is possible to determine if any general relationship exists between them If such a relationship does exist, mechanically equivalent tasks experienced as different will approach a common performance time as they come to be experienced as equivalent

Subjects were asked to give as rapidly as possible the opposite of each of ten words which they read from a typewritten list. Three

lists were used: *A*, consisting of words with a high probability of evoking opposites in a free association test, *B*, of words not so readily associated with their opposites; and *C*, of words which can be considered to have opposites only in one sense or relationship.

A	B	C
up	work	call
hot	start	dive
slow	hill	refrigerator
young	silence	twelve
good	tame	red
high	music	hold
new	hungry	ride
hard	command	anger
wet	sleep	whisper
large	still	bread

The lists were presented in *A*, *B*, *C*, *A*, *B*, *C* order with the order of words changed at each presentation The response words and spontaneous comments were recorded by the experimenter.

The average times of five graduate students in their 12 trials at one sitting are presented in Table 1

TABLE 1

Opposites Tests Mean Performance Times in Seconds

	Test			
Trial	A	B	C	C′
1	9.8	31.7	39.7	11.2
2	11.2	19.7	36.8	9.5
3	12.6	13.9	32.6	9.6
4	9.5	12.5	23.4	8.9
5	9.9	12.3	17.8	8.0
6	9.7	10.7	11.3	9.0
7	9.9	12.0	13.1	8.7
8	9.3	11.0	12.8	8.5
9	8.0	11.5	8.8	8.4
10	8.6	8.6	9.2	9.2
11	8.2	10.8	9.4	9.1
12	9.0	9.1	9.6	8.8

Two subjects were allowed to read list *C* before testing Their results are listed in column *C′* of the table

Results The mean performance times for all lists became approximately equal by the tenth trial, when the average times were

8.6, 8 6, 9 2, and 9 2 seconds. In both list *A*, where the "opposite" response was fluent from the beginning, and in list *C'* there was little improvement during the practice period. While inspection of the gross time scores shown in Table 1 shows improvement *with* practice, the detailed responses of the subjects do not indicate improvement *by* practice In the case of the two subjects who were allowed to find satisfactory opposites for list *C* before being tested on it there was little improvement with further practice In all cases the time curves levelled off as soon as the subject had found the opposites that completely satisfied him The longer performance times in the earlier presentations of *B* and *C* were thus largely due to conscious seeking for satisfying responses Although several words evidently considered inadequate were given, they were always given after a delay during which a "better" opposite had been sought In spite of the insistence on speed in the instructions and the presence of a whirring stop-watch on the table, there were no cases where a subject deliberately chose a short word to save time. The final selections for the opposite of "refrigerator" were "oven," "furnace," "stove," "incubator," and "warming oven." Both of the users of the last two reported that they specifically rejected "stove" because it did not give the exact shade of meaning they required "Incubator" was used in the sense of a laboratory incubator of bacterial cultures as opposed to the refrigerator, which inhibits the growth of micro-organisms. The exponent of "warming oven" shortened his response to "oven" after he had made it clear that "warming oven" was meant. Another subject who had alternated between "write" and "hear" for "call" expressed great satisfaction when she hit upon "beckon"

The longer performance times in the first presentations of *B* and *C* may be largely attributed to this conscious seeking for a satisfying response. When a completely satisfactory opposite was found it was thereafter evoked fluently. Relatively unsatisfactory responses were often repeated but only after an effort to find a more pertinent word The effort would be renewed momentarily on subsequent presentations until the satisfying response was found.

The only evidence of any other type of improvement was the report of a subject whose time on list *A* suddenly dropped from 8 3 to 6.8 "I didn't have to think 'up-down' that time. It was just 'down.'"

Summary. Subjects were asked to name the opposites of words of various degrees of ambiguity. As soon as appropriate opposites were found for all words the completion times of the various lists tended to become equal. In spite of frequent use, a response inappropriate to the subject's concept of the stimulus word was always slow because he first sought a better. The satisfactory response was always fluent

Conclusion In this experiment mechanically equivalent tasks initially experienced as different were performed in the same time as they became equivalent in experience

Experiment 2

Although the results of the first experiment indicate a relationship between the way the task is experienced by its performer and the time required for completion, the method used was quite inadequate for any precise investigation of the relationship Since this lack of precision is due to the inability of the experimenter to share the experience of the performer except at second hand, it would be more satisfactory to present the subject with a task which can be experienced in either of two quite different ways, both of which are known to the experimenter In the following experiment the task was the reproduction of a series of letter triads which could be viewed as nonsense material or as a familiar poem. In order to make group testing possible, the speed of performance was rated by the number of triads reproduced in unit time, instead of total performance time.

Forty-one pupils in a senior third (sixth grade) class were allowed to study a 20-line list of nonsense syllables and consonant triads for two minutes They were then asked to write in one minute the triads they remembered Three different lists were used, the first ten lines of each running

I	II	III
era	und	for
und	era	men
ead	spr	may
spr	ead	com
che	ing	ean
ing	che	dme
utt	stn	nma
stn	utt	ygo
the	ree	but
ree	the	igo

List I was given three times in succession. In the fourth and fifth trials list II was used. This, while consisting of the same triads as list I, needed only regrouping to spell out the opening lines of Longfellow's *Village Blacksmith*, with which the children were familiar. The sixth exposure was of list III, and the seventh and eighth of list II. The children were told that they were being tested to see who could learn the fastest and no comment was made on the results. One week later, at the same period, the experimenter re-entered the room and asked the children to write out as much of the material as they could remember Writing time was limited to five minutes At the end of that time they were asked to report in writing any device they had used to assist in remembering the lines.

Results Fifteen pupils reported that they had remembered the triads as the opening lines of the *Village Blacksmith;* three used individual mnemonic devices; 23 made no report. The previous reports of the 15 who reported recognition of the poem were examined and indications of recognition during the test were found in the reproductions of eight The other seven had failed to reproduce the syllabic order and had apparently learned the principle from classmates after the original test. Averages of the four groups are given in Table 2.

The features at once evident are.

1. The close similarity of the results of the three main groups in the first three trials where the principle was securely hidden.

TABLE 2

AVERAGE NUMBER OF TRIADS REPORTED PER TRIAL

Trial	Group A 8 Discovered principle	B 7 Tutored in principle	C 23 No report	D 3 Individual devices
1	7 25	6 43	6 43	6 67
2	10 38	9.86	9 23	8.00
3	11.50	11 43	11 00	8 67
4	10 87	12,14	11 05	8 67
5	12 50	13 43	11 67	10 67
6	12 25	9 00	9 50	10.00
7	14.25	11 13	11 77	10 00
8	15 25	12 43	13.18	10 00
Recall	18 50	12 13	8.23	5.00

2 The superiority of the group which later reported discovering the poem (group *A*) in the results for trial 6 when the "for men may com . ." verse was given its only presentation. The individuals discovering the principle previously now applied it to the new poem.

3. The continued superiority of group *A* when list II was again presented in trials 7 and 8 Individuals deriving the principle for the first time in trial 6 now applied it to the earlier list

4 The marked superiority of group *A* in delayed recall. In this test, in which five minutes were allowed for report instead of two minutes as allowed in the practice series, group *A* reported more triads than on any previous trial. No individual in the three other groups scored as high as the group *A* average

5. The similarity of groups *B* and *C*, neither of which had discovered the "poem principle," during the practice series

6. The superiority in delayed recall of group *B* (which learned the principle from classmates after the practice series) over group *C*.

7 The inferiority of individual mnemonic methods, as used by group *D*

It should be noted that not all of the eight members of group *A* had derived the principle until the eighth trial Using correct order as a criterion, two individuals had recognized the principle at the fourth, four at the sixth, five at the seventh, and eight at the eighth On the eighth trial only four individuals in the other groups (12 per cent) made a score equal to the average of group *A* In the delayed recall test none of the other 33 members of the class scored as high as the group *A* average.

The scores on these two trials correlated .30 and 28 respectively with National Intelligence scores and —01 and —01 with class standing

Summary. Forty-one senior third-grade children were asked to learn lists of nonsense syllables constructed on a hidden principle. The final average score of the children finding the principle was 123 per cent that of the children not finding it

In a surprise test one week later the children who had discovered the principle reported on an average 225 per cent as many syllables as the other children and 14 per cent more than in their own last practice trial

The delayed recall score of the children who had learned the principle from playmates between practice series and recall was 98 per cent of their final practice series score.

The delayed recall score of children not reporting the principle was 62 per cent of the final practice score

Conclusions. Children discovering the hidden principle were somewhat superior on immediate recall and markedly superior in delayed recall to children using other methods. The way in which the task was experienced considerably affected the amount of work accomplished

All the children who found one hidden poem were able to apply the same general principle in finding another.

EXPERIMENT 3

In the last experiment the children showed an ability to discover and use general principles. Having found that one list of nonsense syllables could be recognized as a familiar poem, they sought to find hidden poems in other lists. The following experiment was devised to investigate the question: Do people tend to use such general principles or procedures in solving groups of similar problems; and if so, do these modes of attack affect the performance time of the several tasks?

Five graduate students were individually asked to find the next three numbers in each of the following series:

I	1	2	3	4	5	6	7	8	9
II	15	14	13	12	11	10	9	8	7
III	1	5	2	5	3	5	4	5	5
IV	9	4	8	4	7	4	6	4	5
V	9	1	8	2	7	3	6	4	5
VI	1	15	2	14	3	13	4	12	5
VII	2	17	12	3	16	12	4	15	12
VIII	26	14	5	25	14	6	24	14	7
IX	5	12	1	6	11	2	7	10	3
X	9	1	19	8	2	18	7	3	17
XI	19	1	9	10	18	2	8	11	17
XII	2	4	6	8	10	12	14	16	18
XIII	1	2	4	8	16	32	64	128	256
XIV	1	2	4	7	11	16	22	29	37
XV	1	3	6	4	7	21	18	22	88

Results. The method of procedure was inferred from the written calculations which the subjects used in their solutions.

The performance times of the subjects were found to divide themselves into two groups in accordance with the mode of attack adopted. The performance times of the individual subjects *A*, *B*, *C*, *D*, and *E*, on each problem, are given in Table 3

TABLE 3
NUMBER SERIES PROBLEMS SOLUTION TIMES IN SECONDS

	Group I			Group II	
Problem	A	B	C	D	E
I	4.3	4 4	2 7	2 8	2 2
II	4 0	4 5	2 9	3.4	2 9
III	7 8	8 7	7 9	21 8	30 5
IV	5 7	4 3	4 2	47 4	23 6
V	11 5	6 3	17 9	27 8	45 3
VI	6 0 -	6 4	8 7	44 6	16 3
VII	17 2	21 0	15 9	138 4	495 2
VIII	14 1	20 4	9 9	106 0	31 0*
IX	16 6	9 2	13 2	134 8	18 1
X	8 3	11 4	15 1	31.8	18 1
XI	14 8	22 5	11 7	81 3	21 4
XII	10 6	15 0	2 9	3 7	6 2
XIII	17 5	29 8	15 9	23 6	9 8
XIV	19 3	31 1	16 6	10 1	11 1
XV	Failed (960)	613 0	771 3	241.5	423 0

*Used either method from this point

Although all subjects were given the same instructions, there was a sharp difference in completion times beginning with the third problem. *A*, *B*, and *C* recognized that series as 1, 2, 3, 4 . . with an intervening constant, 5 *D* and *E*, however, found a secondary relationship in the differences of the successive digits, 4, —3, 3, —2, 2, —1, 1, —0, 0 and completed the series by adding 1, —1, and 2 to secure the correct answers. They solved the problem in 21 85 and 30.55 seconds as compared with 7.85, 8.76 and 7 95 seconds for *A*, *B*, and *C* Beginning each solution by finding the differences between the successive numbers, *D* and *E* were markedly slower in performance time up to and including problem VII, which they solved in 138 4 and 495 2 seconds respectively as against an average of 14 5 seconds for *A*, *B*, and *C* *E* thereafter adopted the method used by group

I, seeking the component series directly in the presented material, and her time scores fell to the general level of group I.

Up to this time group I had been uniformly superior Its simpler and less cumbersome procedure, however, proved quite inadequate for the solution of problem XV The fastest solution by a member of group I was 10 minutes 13 seconds, while *A* failed to find the solution in 16 minutes. *D* and *E*, on the other hand, solved the problem with little difficulty, in four and seven minutes respectively

Summary Comparison of two small groups solving the same problems by different principles shows:

1. Marked time superiority for the group using the more direct principle where that principle was adequate for solution. In one case the problem was solved by this group in 6 per cent of the time required by the other group.

2. Equally great superiority in other problems of the group using the other principle.

3. There was little change in methods of procedure during the test. The performance time of the various subjects on problem XV was largely determined by the principle of solution they used in the third problem.

Conclusions.

1 In this situation the chief determinant of the performance time was the general principle employed in the solution of the problems

2 There was a strong tendency to preserve unchanged any principle which leads to solution.

3. Changes of principle did occur in cases where the old principle had proved inadequate. The written work indicates that *E* altered his mode of attack after the first method had proved cumbersome in the seventh problem. All subjects solving problem XV eventually solved it by using the group II principle of finding the intermediate relationships

4. The results conform to those of Husband in his investigation of methods used by human subjects in maze running He concluded that

> much of the high variability which has always characterized maze results was found to be due to the many different methods used in learning Each method, as employed by

different learners has its own mean, with cases clustered about it (1, p 274-275)

He also found that the methods were carried over by the subjects into new tasks.

Experiment 4

In the experiments conducted up to this point we have compared the difficulty of two tasks mechanically equal, but experientially different, and found that they became of equal difficulty, measured in performance time, as they became experientially equivalent We have compared the performance times of the same task by different individuals and have found that the performance time is largely determined by the subject's mode of attack We have seen that this mode of attack is not peculiar to the individual problem but is in conformity with general principles which govern the individual's procedure in like situations and that the relative efficacy of these principles may vary with phenomenological changes in the task

These indications, that differences in the difficulty of two mechanically equivalent tasks are concomitant with phenomenological differences, appeared to require verification in a situation where comparison could be made not only between two groups experiencing the same task in different ways but between mechanically equal tasks experienced in different ways by the same individual.

Such a comparison is made possible in the cancellation of the material shown in Figure 1. Of the 18 different symbols that appear in each block, five contain curved lines, five contain one or more right angles, five are triangles, and seven are miscellanous figures. The total number of symbols containing curved lines is 26; of lines containing right angles, the same; of triangles, 22 The cancellation of the symbols containing curved lines is mechanically equivalent to the cancellation of the figures containing right angles in the sense that both involve the same number of pencil strokes distributed fairly evenly over the same area.

Part 1

Subjects. Eighty-eight students in a second-year undergraduate laboratory course acted as subjects in the first part of the experiment, which was conducted as a group test.

Procedure. The subjects were issued mimeographed sheets of the material to be cancelled and were shown one of the three lists of symbols to be cancelled as shown in Figure 1. List *A* consists of

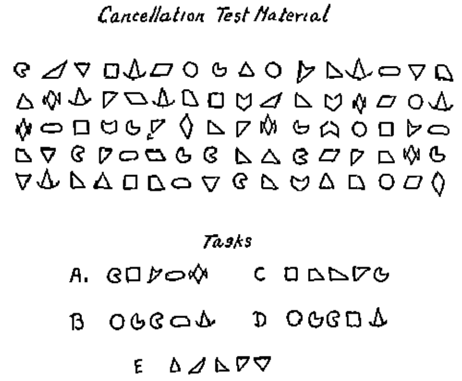

FIGURE 1.

five miscellaneous figures, list *B* of all the figures containing curved lines, and list *C* of all the figures containing right angles. After cancelling the required figures in the first block as rapidly as possible the subjects were asked to make a note of anything which had helped them to remember the symbols to be cancelled and were instructed to do the same for the other two lists, cancelling each list in turn until each had been cancelled in six blocks. Each subject timed himself.

Results. Forty (45 per cent) of the subjects reported that they discovered the principle "cancel all figures with curved lines" in performing task *B*. Twenty-one others reported that they had used the concept "three circles, any oval, and a 'do-funny'" in this task. The remaining 27 reported no principle.

The average performance time of the last trial shows a clear relation between the concept derived and the performance times shown in Table 3*A*.

Of the 40 subjects who recognized the task as the cancellation of all symbols containing a curved line, every one made faster time on the sixth trial than the average of the individuals who did not report any concept of the symbols. Conversely, only one member

TABLE 3A

AVERAGE PERFORMANCE TIMES, TASK *B*, LAST TRIAL

	Principle	F	*Seconds*	Subjects slower than av. of *group 1*	Subjects faster than av of *group 3*
1	(No concept)	27	41 6±12 4	28%	4%
2	(Three circles)	21	32 0±5 8	5%	10%
3	(All curves)	40	24 1±6 5	0%	50%

of this "no concept" group was able to perform the task as quickly as the average member of the group deriving the principle. The subjects using the concept "three circles, the oval, and the pie" were intermediate to the other two groups in performance time, only one of the 21 being as slow as the average member of the "no concept" group and only two as fast as the average of the "curve concept" group

The average superiority of 17.5 seconds which the "curves" group had over the "no concept" group is exactly equal to the average improvement made by all subjects on the first trials on which the concept was reported. The abrupt improvement occurring at this point may be easily traced in Table 4 Two features of the per-

TABLE 4

MEDIAN PERFORMANCE TIMES OF SUBJECTS REPORTING THE PRINCIPLE "CANCEL ALL CURVED LINES"

F	Trial *reported*	1	2	3	4	5	6
13	1	*32*	30	28	22	23	20
5	2	70	*35*	29	27	24	24
3	3	53	48	*33*	36	27	20
6	4	62	45	43	*33*	32	32
7	5	60	53	54	43	*30*	25
6	6	52	50	35	35	42	*24*

Explanation 13 *subjects reported that they had used the principle on the* first trial The 5 subjects who reported using it for the first time on the second trial averaged 70 seconds for the first trial, 35 for the second, and 29 *for the third*

formances of task *B* are at once apparent in this table the uniformity of the performance time at which the principle is first reported, and the comparatively small degree of improvement thereafter Among the subjects reporting the concept later than the first trial,

the average improvement on the trial immediately preceding the report was 17.5 seconds, the average improvement on other trials was 3.4 seconds.

Only 18 subjects reported the discovery of the principle "cancel all symbols containing right angles" in task *C*. Those who did were superior in this task to the 70 other subjects, who reported less inclusive concepts, or none at all:

TABLE 4*A*

Average Performance Times, Task *C*, Last Trial

Principle	F	Seconds	Slower than 4	Faster than 5
4. (No concept)	70	43 7±14 1	45%	13%
5 ('Right angles')	18	35 8± 9.2	28%	55%

No subject reported any inclusive concept for the symbol to be cancelled in task *A*. The mean final time for the 88 subjects was 45 7±15.1 seconds Thus where no principle was reported there was no reliable difference in the performance times of the three tasks, the final averages being 45 7±15 1, 41.6±12 4, and 43 7±14 1 seconds for *A*, *B*, and *C*. The graph in Figure 2 shows how similar was the

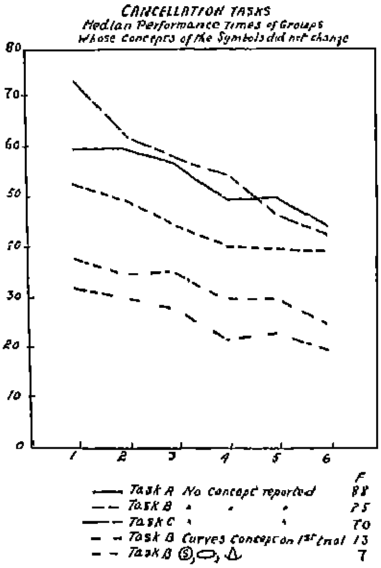

FIGURE 2

course of improvement among these tasks. *It is interesting to note in this figure* the nature of the curve which describes the performance times of the 13 individuals who reported the "curved line" concept at the end of their first trial in task *B*. It follows a course similar to that of the "no concept" curves but is faster throughout. The performance times of groups who derived the "curved line" principle at a latter stage show a sudden drop from the higher to the lower level as the concept is reported, as shown in Figure 3

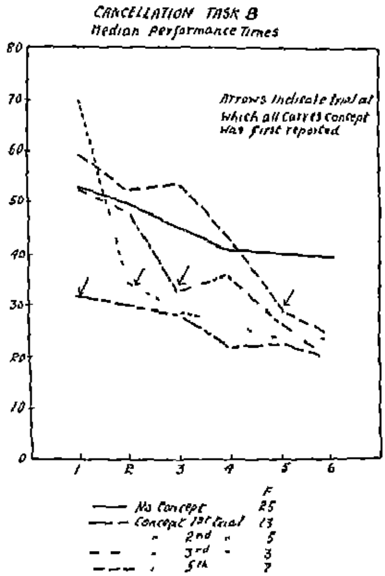

FIGURE 3

Summary. When three mechanically equivalent cancellation tasks were performed by 88 subjects the performance times of the sixth trial proved to be a function of the subjects' concept of the symbols to be cancelled.

In the same task the concepts were effective in the order of their parsimony "Cancel all curved lines" was performed in an average time of 24.1 seconds; "cancel all circles, the oval, and the piece of pie" in 32 0 seconds; and the average time of subjects using all other methods was 41 6 seconds.

When two principles were equally parsimonious ("cancel all curved lines" and "cancel all figures containing right angles") the principle involving the least perceptual differentiation in its use was the more effective by 24.1 to 35.8 seconds

Part 2. The symbol cancellation was continued by five graduate students with one or more trials daily for a period of three months In addition to the tasks used in the group experiment these subjects also performed task *D*, which was the same as *B* except that the square was substituted for the oval, making the principle "cancel all curves" inapplicable Task *E*, which could be performed by cancelling all triangles, was performed by all subjects until the concept had developed and thereafter continued by only one subject.

At the end of 90 trials the subjects were tested by being asked to cancel the required symbols from material in which the order of the symbols had been changed.

Results. The results in general conform closely to those of the first section. Task *B* was, even after 90 trials, the easiest for all the subjects who performed the tasks in rotation. In the case of the one subject who performed both *B* and *E*, the two tasks amenable to solution by the most parsimonious principles ("cancel all curves" and "cancel all triangles"), the performance times were almost equal, with *B* slightly superior The "curves" could be judged on the basis of the bottom line, while more complete perception of the "triangles" was necessary since there were several other angular figures in the material

D, differing from *B* in only one symbol, required about 25 per cent more time for performance throughout While all subjects used the principle "cancel all curves" in task *B*, the concept in *D* was "the circles, the square, and the pie" The performance times of the subjects in Part I who had used a similar concept "the circles, the oval, and the pie" for task *B* had closely approximated the times of the group using the more parsimonious but perceptually more difficult concept "cancel all right angles" in task *C* All the subjects in this section used this "right angle" principle in solving *C*, and the close correspondence of performance times with those of *D* may be seen in Table 4

In those tasks, *B*, *C*, *D*, and *E*, where general concepts of the group of symbols to be cancelled were derived, the individual per-

formance times showed marked drops when the concept was reported. *B*, *C*, and *E* offer the most inclusive and consequently parsimonious concepts, "all curves," "all right angles," and "all triangles"; and the performance times were in order of the perceptual difficulty of applying the concepts: *B*, *E*, and *C*.

It will be noticed that the performance times for task *A*, while showing a more gradual rate of drop, came by the twentieth trial into the approximate level of tasks *C* and *D*. Although the use of explicit principles and concepts had greatly accelerated learning at first it may be possible that in some cases the adoption of a static principle may "freeze" the performance and prohibit further progress. Something of the sort may have occurred in Vincent's (3) experiment where the rats given visual cues made much greater initial progress but were eventually excelled in performance time by the animals who did not use visual cues and did not have to slow down to watch for them.

The results of the previous experiments in this series had led the experimenter to anticipate this result. To check this possibility one subject was not asked to learn task *A* until he had completed the others. He was then told that it was not possible to derive a compact, inclusive concept of the task *A* symbols, but that he could use any method he wished in learning the task. He determined to learn the location of each symbol to be cancelled and in two weeks, as shown in column *A'*, Table 4, he had, by the aid of a rhythm he discovered in the material, reduced the time of cancelling the 22 symbols to 3.6 seconds. His best time for task *B* had been 6.4. When tested, however, on the same material in changed order his time for *A* rose to 26.5 seconds, while *B* was performed in 8.1. In *A* he had learned to mark certain locations, in *B* he had learned to cancel curved lines. The learning in *A* was applicable to only one block of symbols, that in *B* to any situation where there were figures with curved lines.

All subjects, as shown by the persistent omission of certain symbols, learned to depend partially on the spatial position of the symbols to be cancelled. Judging by the comparative increases in time when tested on cancellation of new material, the dependence on location was much greater in *A*, where no parsimonious principle of performance was possible.

Summary. Four mechanically equivalent cancellation tasks were performed 90 times each by five subjects.

A list of symbols which could be cancelled by use of the principle "cancel all curved lines" was cancelled at least 25 per cent faster than the same list in which a square had been substituted for an oval to make performance by the single principle impossible.

TABLE 5
SYMBOL CANCELLATION MEDIAN TIMES OF FIVE SUBJECTS

	Task				
Trial	A	B	C	D	A'*
1	46.6	41.4	56.0	57.6	25.3
10	35.7	17.1	28.8	26.4	14.3
20	20.5	15.0	20.0	21.3	13.8
30	16.9	14.6	20.3	18.5	9.6
40	16.5	11.6	18.5	16.5	8.7
50	15.3	11.2	16.4	13.8	6.6
70	13.3	10.0	14.2	14.8	4.6
90	12.0	9.0	12.8	11.4	3.6
Test	25.7	13.9	19.2	16.4	26.5

*One subject only. See test.

The task which could be performed by cancelling all curves was performed faster in all cases than the task which could be performed by cancelling all right angles.

The relative difficulty of the tasks, measured either by initial rate of improvement or by speed in cancelling from new material, was determined by the degree of parsimony of the principles of procedure and by the perceptual difficulties involved in their use.

GENERAL SUMMARY

The results of the five experiments on human subjects which have just been described appear to warrant the following conclusions:

1. Difference in difficulty between two mechanically equivalent tasks corresponds to a difference in the way the two tasks are experienced (Experiments 1, 2, 4).

2. Individuals solving problems use general principles and methods of procedure (Experiments 2, 3) which are modified according to the exigencies of the situation (Experiment 3).

3. The relative speed of learning among mechanically equiva-

lent tasks is determined by the degree of parsimony of the principles required for performance, and by the perceptual difficulties involved in the application of these principles (Experiments 2, 3, 4).

4. There are some indications that the greater speed of learning of tasks amenable to performance by parsimonious principles is also associated with greater efficiency in delayed recall (Experiment 2) and, what may be the same thing, with greater transfer (Experiment 4)

Accepting for the moment the validity of these conclusions, their implications for pedagogy are unmistakable. Where, as in most educational situations, the prime consideration is the acquisition of an adequate performance in the shortest possible time, the comparative times necessary to bring two alternative tasks to the required standard of performance are of prime importance If it is possible to predict which of two equivalent tasks will be learned the faster it is possible to predict how any task may be altered to accelerate mastery

In the next section the validity of the third conclusion will be tested by applying it to prediction of the maze-running performances of white rats

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LA DIFFICULTÉ RELATIVE DES TÂCHES MÉCANIQUEMENT ÉQUIVALENTES· I L'APPRENTISSAGE HUMAIN

(Résumé)

On a fait cette étude dans le but d'examiner expérimentalement la nécessité des suppositions de la relation entre l'expérience et l'activité du type suggére dans les expressions 'possession', 'connaissance profonde', et 'moyens—buts—relations' La methode générale a compris une étude de

l'effet sur l'exécution des différences empiriques entre les tâches qui exigent une activité motrice identique ou équivalente Avec une réponse motrice d'une sorte équivalente il est possible de faire des situations où l'on peut contrôler d'autres conditions 'objectives' et comparer directement les différences dans l'exécution ou dans le temps de l'apprentissage avec les différences phenomènologiques entre les tâches

Dans une série d'expériences comprenant l'association contrôlée, la mémorisation des triades de lettres, la complétion de séries de numéros, et la cancellation de symboles il paraissait que le temps necessaire pour l'exécution d'une tâche a été dépendant de la conception de la nature de la tâche par le sujet, plus le principe employe dans l'execution a été parsimonieux et plus la différenciation perceptive essentielle à son application a été manifeste, plus son exécution a été efficace.

SNYGG

DIE RELATIVE SCHWIERIGKEIT DER MECHANISCH GLEICHWERTIGEN AUFGABEN I DAS MENSCHLICHE LERNEN

(Referat)

Der Zweck dieser Forschung war die experimentelle Untersuchung der Notwendigkeit fur Annahmen uber das Erfahrungs-Tatigkeitsverhaltnis von der Art, die bei Ausdrucken wie "Zugehoren," "Einsicht," und "Mittel-Zielverhaltnisse" vorkommen Die allgemeine Methode gebraucht eine Untersuchung der Wirkung der Erfahrungsunterschiede zwischen Aufgaben, die identische oder gleichwertige Motortatigkeit verlangen, auf die Leistung Bei Motorreaktionen, die gleichwertig sind, ist es möglich, Situationen aufzustellen, wo andere "objektive" Umstande kontrolliert und Unterschiede in der Leistungs- oder der Lernzeit unmittelbar mit phanomenologischen Unterschieden zwischen den Aufgaben verglichen werden konnen

In einer Reihe von Experimenten uber kontrollierte Assoziation, das Auswendiglernen von Buchstabendreizahlen, Zahlreihenerganzung, und Symbolausstreichung erschien es, dass die notige Zeit zur Ausfuhrung einer Aufgabe von der Vorstellung der Person uber die Natur der Aufgabe abhangt, je sparsamer der gebrauchte Grundsatz in ihrer Ausfuhrung und je augenscheinlicher die Wahrnehmungsunterscheidung, die zu dessen Anwendung notwendig ist, desto wirksamer ist ihre Leistung.

SNYGG

THE RELATIVE DIFFICULTY OF MECHANICALLY EQUIVALENT TASKS II. ANIMAL LEARNING*

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DONALD SNYGG

In the first section of this investigation (6) an attempt was made to examine experimentally the necessity for assumptions of experience-activity relationships of the type implied in the expressions "belonging," "insight," and "means-end-relations" The method involved the presentation to human subjects of tasks requiring identical or equivalent motor activity With the motor responses equivalent it is possible to attribute differences in amount of performance or in learning time to phenomenological differences between the tasks, and thus to examine objectively the experience-activity relationship Under such conditions it was found that the time required for performance of a task was dependent upon the subject's conception of the nature of the task The more parsimonious the principle and the more obvious the perceptual differentiation essential for applying it, the more complete the performance in terms of the criteria used.

As a general thesis applicable to the whole field of behavior of learning, the conclusion suffers from the narrow field in which it was derived The tests in general were of an abstract type requiring a minimum of motor activity. Will the hypothesis prove valid in the learning of motor activity by animals? In the following section it is purposed to test the validity of the hypothesis in maze learning by white rats

MAZES

The mazes used in the following experiments were ten-section modified Warden U-mazes (3), the individual sections having built-in floors and being fitted with a tongue at the exits and groove at the entrance for easy shifting All sections were identical except that the interiors of the sections used in the visual mazes were painted

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white on one side and black on the other, the dividing line running down the wall and floor directly in the middle of the entrance The other maze sections were painted black Since ten sections were used in all cases all paths were of equal length and number of turns Doors to prevent retracing were used only at the starting-box exit and the food-box entrance

PROCEDURE

The animals used were purchased from a local dealer and were five to seven weeks old when the experiments were begun As a preliminary training the animals were fed in the food box of the maze for five days. During the experiments two runs were made each day at an interval of nine hours. The animals were allowed to feed two minutes in the food box and were then removed to the feeding cage. No food except lettuce was supplied in the home cage.

The criterion of learning was three errorless runs in four consecutive trials. The placing of both front feet into a blind alley was scored as an error.

EXPERIMENT 1

What is the comparative difficulty of a maze constructed on a visual principle (correct path black, blind alleys white) with a conventional maze of identical pattern and dimensions?

Mazes. Maze *B*: a Warden U-maze of the standard LRRRLL-RLLR pattern (3, 8)

Maze *B-W*: An identical maze with the blind-alley half of each section painted white.

Subjects Two groups of white rats, 13 in each group The groups were equated for weight and there were six males and seven females in each group

Procedure. Group 1 was run in maze *B* and Group 2 in maze *B-W* for 45 trials each The groups were then interchanged, Group 2 being run in maze *B* for 45 trials and Group 1 in maze *B-W* for 30.

Results 1. The maze constructed on the visual principle was learned the more rapidly by seven and six trials as compared to 45 and 34.

TABLE 1

	Median trial learned	Range	Number learning	Percentage learning	Fastest time
Maze *B*					
Group 1	34	14- ?	7	54	7 4 (43)
Group 2	45	3- ?	7	54	7 4 (26)
Maze *B-W*					
Group 2	7	5-17	13	100	7.0 (26)
Group 1	6	3-17	11*	100	7 2 (10)

*Two animals died near the end of the runs in *B*.

2. All animals learned the *B-W* maze within 17 trials while only 54 per cent learned the *B* maze in 45 trials.

3. The percentage of perfect runs in maze *B* after fulfilling the criterion of learning was 55 5 for Group 1 and 61.8 for Group 2 The corresponding percentages in *B-W* were 91.8 and 93 4.

4. In maze *B-W* all animals had made nine perfect runs out of 10 consecutive trials by the 24th trial In maze *B* only 20 per cent of the animals were able to reach this standard by the 45th trial.

5 Performance time of the rats in the *B-W* maze, although approached by the rats in the B maze, remained superior to the end of the experiment

6 In spite of the fact that the two mazes were spatially identical, only one animal from each group was able to run the second maze on the first trial after 45 runs in the first maze In both cases the performance time of these animals increased about four times.

7. Of five surviving animals in Group 1 who had learned maze *B*, only one was able to run it without error two weeks after completion of the runs in maze B-W. The others made three, four, five, and seven errors respectively

8 Of the 13 animals in Group 2, seven made errorless runs in *B-W* two weeks after completion of the runs in *B*.

Discussion The objective results of the experiment agree very closely with those of Vincent (9) except that the rats in the *B-W* maze remained throughout superior in performance time and made fewer errors than the animals in *B* It is likely that this difference in results is due to the different position of the visual cues in the two experiments In the present experiment both the black and white

were visible to the rat while he was still at some distance from them and he was consequently able to make his choice without slowing his pace as appears to have been necessary in the Vincent maze. This greater prominence of the visual cues in the present maze may also account for the greater accuracy of the animals in maze *B-W*. Three of the 14 rats who "learned" maze *B* subsequently "forgot" it while the percentage of correct choices for either group in *B-W* never fell below 99.6 after the 20th trial.

Summary. When two comparable groups of rats were run in two spatially identical mazes, one of which was constructed on a visual principle, the group in the maze amenable to solution by derivation of a principle was superior in speed of learning, performance time, and retention.

When the same group was run in both mazes, the performance in the maze constructed on the visual principle was superior.

EXPERIMENT 2

In the preceding experiment the maze constructed on the simple visual principle proved markedly easier to learn than the standard maze of the same pattern. Two questions at once arise:

a. To what extent may the learning of the *B-W* maze have been affected by a natural preference of the animals for dark passageways?

b. The animals in the *B-W* maze had, through the spatial identity of the two mazes, the same possibilities for learning as the animals in the *B* maze, with the additional aid of the visual distinction between correct path and blind alleys. Would the learning take place faster than in the standard maze if animals in the visual maze were forced to rely upon the visual principle alone?

To find an answer for these questions 26 rats were run for one trial in a standard LRRRLLRLLR pattern maze in which the correct pathways were painted white, the blind alleys black. On the basis of their performance in this trial they were divided into two equivalent groups. One group was trained in the test maze, which was designated as the *W-B* constant-pattern maze or *W-BC*. The other group was trained in a maze constructed of the same sections, on the same *W-B* principle, but with the pattern varied according to the flip of a coin for each trial. This was the *W-BV* (*W-B*

variable-pattern) maze Both mazes were made up of the same sections and in every case contained the same number of right and left turns.

Although the usual procedure was as described above, for purposes of comparison the variable group was run in maze *W-BC* every tenth trial On the 11th and 31st trials both groups were run in a mirror image of the *W-BC* maze

Results 1 In the first trial in the *W-B* mazes the animals were correct on only 38 per cent of the choices the first time the choices were made In *B-W*, 62 per cent of the choices had been correct and in *B*, 40 per cent. This would appear to indicate an initial preference for the darker pathway

TABLE 2

	Median trial learned	Range	Percentage learning	Fastest time
Maze *W-BC*	7	5-11	100	6 4 (17)
Maze *W-BV*	10	6-21	100	7 1 (19)

2 Maze *W-BC* was, in spite of this initial preference, learned as quickly as *B-W* had been. *W-BC* was learned in seven trials with a range of five to 11, *B-W* in seven with a range of five to 17

3 Maze *W-BC* was learned earlier than *W-BV* but both were learned much faster than *B* had been.

4. Comparison of the constant and variable groups in the same maze is shown in Table 3

TABLE 3

	Median time		Perfect runs		Median errors	
	C	V	C	V	C	V
Maze *W-BC*						
Trial 1	340 0	319 0	0	0	20	19
10	8 2	8 0	11	7	0	0
20	6 4	8 0	13	10	0	0
30	7 3	7 1	12	11	0	0
W-BC reversed						
11	16 0	10 4	1	8	2	0
31	18 8	8 2	2	10	2	0

The group trained in the variable maze was only slightly inferior in accuracy and approximately equal in performance time to the

constant-pattern group when tested in the constant maze. It was markedly superior in other mazes involving the common principle

Summary. Two comparable groups of rats were trained in two mazes constructed of the same sections and on the same *W-B* visual principle. When the groups were compared in the constant-pattern maze the animals trained in that maze were somewhat superior in accuracy. When compared in mazes of other patterns the group trained in the variable-pattern maze was markedly superior.

The group trained in the constant-pattern maze fulfilled the 3-4 criterion of learning at the seventh trial, the variable-maze group at the tenth

Conclusions. 1 In spite of a considerable difference in incidence of wrong choices on the first trial, there appears to be no significant difference in the difficulty of mazes constructed on light- and dark-path principles.

2 A pure visual-discrimination maze with a variable pattern is only slightly more difficult to run accurately than a constant-pattern maze constructed of the same units; and the individual runs are made in approximately the same time.

3. Animals in the *W-BC* maze depended partly on visual discrimination and partly on pattern. This was true to a lesser degree in the *W-BV* maze.

Experiment 3

In the previous experiments mazes constructed on simple visual principles were learned in from one-third to one-sixth the number of trials necessary to learn standard mazes of the same pattern.

Will the same ease of learning be found in mazes constructed on *parsimonious spatial principles?*

Procedure. Nine animals were trained in a ten-section maze of LLLLLLLLLL pattern; that is, the correct path is always to the left.

Results. 1 The criterion of learning (3-4) was satisfied at the sixth trial The range of the group was from four to six, with no animal making an error after the third trial.

2. Even on the first trial no errors were made beyond the seventh section.

Discussion The median trials required for learning are quite

closely in line with those required for learning mazes of the same length and number of turns constructed on simple visual principles (Experiments 1, 2). The extreme shortness of the range, however, is interesting in view of the findings of Krechevsky (4), which suggest that rats show somewhat greater readiness to adopt spatial than visual hypotheses.

EXPERIMENT 4

The distinction between "principle" and "perceptual difficulty" as determinants of the degree of difficulty of mechanically equivalent tasks does not mean that they are to be thought of as independent of or unrelated to one another, since the chances of any one "principle" being used at all depend upon the perceptual difficulties of applying it

To illustrate the point let us consider the mazes RLLLLLLLLL (*R*1-*L*9) and LLLLLLLLLR (*L*9-*R*1) Both are the same length and contain the same number of right and left turns To a human subject the simplest adequate directions are "around the corner and keep to the left," and "nine sections left and then right" The difference is not in the parsimony of the statements but in the perceptual difficulties of carrying them into effect. The first involves the perceptual differentiation of the maze into two parts, the second demands its differentiation into ten sections, the first nine individually distinguished from one another by the verbal designations "one, two . nine."

Since the differentiation necessary for the derivation and use of the principle adequate for performance of *R*1-*L*9 should be possible in less time than the more complete differentiation necessary for the solution of *L*9-*R*1 (1), it should be expected that human subjects will learn the former maze more quickly than the latter.

With rats the difference in difficulty between the two mazes would be accentuated since the principle of solution of maze *L*9-*R*1 involves a mechanism of verbalization which they cannot command. If the results of Spragg (7) are applicable to this situation, the *L*9-*R*1 maze should be practically insoluble by rats Spragg ran four rats for 100 trials in a Walton U-maze of RRRRRRRL pattern and found that none of them was able to master the problem.

Suppose, however, that a visual sign or cue is placed in the en-

trance to the tenth section of the *L9-R1* maze. There is now the possibility of solution by derivation of the principle "left to the sign, then right"; and, if our postulates are correct, the chances for such a solution will increase with the size or impressiveness of the visual cue.

We now have two mazes, *R1-L9* and *L9-R1*, amenable to solution by what we may designate as principles of the second degree of parsimony (to distinguish them from the unitary principle adequate for maze *L10* in the last experiment). Although these two mazes do not differ in parsimony of principle they do differ considerably in the manner in which the principles are applied In view of the reported tendency of rats to use spatial cues, which will be adequate in *R1-L9* and inadequate in *L9-R1* (2) we should predict that *R1-L9* would be slightly more difficult to master than the more parsimonious *L10* and that the difficulty of *L9-R1* would vary above this limit with the character of visual cue used.

The experiment was carried out simultaneously with Experiment 3 to allow comparison with the results of *L10*.

Mazes *L9-R1*, no apparent differential cues except a piece of white crayon laid in the entrance to the blind alley in section 10

R1-L9, no apparent differential visual cues

Subjects. Nine white rats chosen by lot simultaneously with the animals used in the previous experiment were run in each maze. Unfortunately one of the animals in *L9-R1* died early in the experiment so the results of this group are for eight animals.

Procedure. The amount of crayon placed in maze *L9-R1* was varied beginning with the 31st trial, as indicated below

TABLE 4

	Trial learned	Range	Percentage learning	Best time	Trials run
L10	6	4- 6	100	6 8(6)	10
R1-L9	6	5-18	100	6 3(8)	20
L9-R1	41	24-69	100	7.3(54)	80

Results. 1. Since *R1-L9* was learned in a median of six trials with a range of five to 18, and *L10* in six with a range of four to six, the difficulty of *R1-L9* was, as had been expected, only slightly greater than that of *L10* Both approximated in difficulty the

unitary-visual-principle mazes investigated in the earlier experiments.

2. *L9-R1* was learned more slowly and was never run with any degree of consistency by any animal. Although all animals passed the criterion of three perfect runs out of four consecutive trials, none passed a nine out of 10 criterion.

3 During the first 30 trials in *L9-R1* the percentage of perfect runs for each five trials was 12, 2, 5, 18, 25, and 12 The number of pieces of crayon in the cue position was then increased to 10 and the percentage of errorless runs rose to 28, 38, 43, 53, and 60. In the succeeding runs one piece of crayon was removed at the end of each run During this period the perfect runs stood at 50 and 55 per cent The percentage did not fall at once upon the exhaustion of the crayon, for the percentage on the next five trials was 57. It then dropped to 28 and 25 per cent, at which point the experiment was discontinued

Experiment 5*a*

In the previous experiment, in which two mazes amenable to solution by equally parsimonious principles were tested by comparable groups of white rats, one maze proved decidedly more difficult to master than the other. On the basis of our hypothesis such a difference must be accounted for by the perceptual difficulties of discovering or applying the postulated parsimonious principle. If this is true there are two ways in which it should be possible to teach the difficult *L9-R1* so that it might be learned in as short a time as the "easy" maze *R1-L9*.

The possible methods of decreasing the difficulty of the perceptual task are: (*a*) increase the size or vividness of the feature of the situation whose perception is necessary to solution, and (*b*) train the learners in other situations where the perception and recognition of similar signs are necessary.

Due largely to the accident that the only animals immediately available in the laboratory were four young rats who had been used in a motion picture demonstration of the *B-W* maze described in Experiment 1, both methods were used in the present experiment These animals had run from one to five trials in the *B-W* maze whose principle was "avoid the white." The maze now used was the *L9-R1* pattern, as used in Experiment 4, except that the last

blind alley was painted white as in the visual mazes reported in Experiments 1 and 2.

Results The maze was learned in six trials with a range of four to six.

Conclusions The greater difficulty of maze *L*9-*R*1 in the previous experiment when it was learned only after 41 trials, as against six in the present experiment, was due to lack of perceptual prominence of the essential cues.

Experiment 5*b*

Was the performance of the animals who learned the *L*9-*R*1 maze so readily based upon the pattern or the principle of the maze? Although the rapidity of learning is almost enough to dispose of the first possibility without comment the question was answered by running the animals in an *L*10-*R*1 maze on the 7th trial and in an *L*8-*R*1 maze on the 8th. In both cases the last section had a white blind alley All four subjects ran the maze without error in each case.

Changes in the spatial character of the maze did not interfere with performance so long as the principle on which the maze was constructed remained unchanged

Experiment 5*c*

It does not necessarily follow, however, that the principle used by the teacher in planning a problem is the one used by the pupil in solving it. This lesson, learned in Experiment 3, Section 1 (6), was again impressed upon the experimenter by the behavior of the animals in the maze *L*8-*R*2 in which they were placed at the next trial. This maze, in which the ninth section had the white blind alley, was constructed by the experimenter on the principle, "Correct path to the left, then right at the white section" If the animals had derived this principle they should have run the *L*8-*R*2 maze without error Only one of the animals was able to do this; the other three turned left again at the tenth section. Two of these pushed and clawed at the door at the end of this blind alley for several seconds in a manner eloquent of confidence in the correctness of their choice. Their behavior conformed to the principle

"left but stay off the white," which would have been quite adequate for all the mazes they had run up to that point.

After further training in the *L8-R2* maze, in which the criteria of learning were satisfied in five, 13, and 14 trials by the three animals who had erred on the first run, three of the four animals ran the maze *L8-R3*, also constructed on the "left to white, then right" principle, on the first trial The animal who had run the *L8-R2* pattern without error from the first trial was the one who made the only mistake

At this point the group had made 23 runs in five maze patterns all based on the principle "left to the white, then right." This principle also governed the construction of the maze with the crayon cue, used in the Experiment 4 maze. When the rats used in the present experiment were placed in the Experiment 4 maze (*L9-R1*) all made errorless runs on the first trial, their 24th in mazes constructed on this "left-sign-right" principle In the same evening only three of the eight animals in the Experiment 4 group, then in their 43rd trial in this maze, made errorless runs

In spite of this successful run on the first trial the four animals were not able to repeat it on the next. The difference in the character of cue used at the crucial section thus had its effect, not on the first but on the following trials The performance of these animals fell to the approximate level of the Experiment 4 group, already reported, and it was not until 20 trials later that the initial record of 100 perfect runs was equalled.

Summary. Four rats were run in mazes, all constructed as follows: the correct choice was always to the left until a white surface was encountered. From there the correct choices were to the right

After mastering an *L9-R1* pattern all the animals were able to run *L10-R1* and *L8-R1* mazes without error on the first trial. One of the four was able to run an *L8-R2* maze without error on the first trial.

After mastering *L8-R2* maze, three of the four ran an *L8-R3* maze without error on the first trial. All were then able to run without error an *L9-R1* maze in which the cue for a change in direction was a pile of white crayon instead of the white surface. This performance, made on the first trial, was markedly superior to that

of animals who had been trained in the test maze, and to their own performance in subsequent trials in the same maze

SUMMARY

Eight comparable groups of white rats were trained in one or more ten-section Warden U-mazes. With three errorless runs in four consecutive trials as the criterion of learning, mazes constructed on simple visual or spatial principles were learned in only 17 per cent to 29 per cent as many trials as the standard maze of the same number of sections

1. Mazes in which the correct pathway was lighter or darker than the blind alleys were learned in seven trials as against the 34 trials required for the standard maze of the same pattern (Experiments 1, 2).
2. A variable-pattern maze constructed on the simple "light pathway" principle was learned in 10 trials (Experiment 2)
3. The maze constructed on a parsimonious "all left" principle was learned in six trials with a range of four to six, while the RLL-LLLLLLL "right, left" principle maze was learned in six trials with a range of five to 18 (Experiments 3, 4).
4. A putatively insoluble maze (LLLLLLLLLR) was learned in 41 trials when crayon was placed in the entrance to the last *blind alley; and in six trials when the last blind alley* was painted white (Experiments 4, 5).
5. When a group of animals was trained in five mazes constructed on the principle "left to the white blind alley, then right" the behavior in each new maze was in accordance with principles which would have been adequate for the solution of all the mazes run up to that time (Experiment 5*b*)
6. Animals trained in a number of mazes constructed on the same principle were much more successful in running other mazes constructed on that principle than were animals whose training had been confined to one maze (Experiment 2).

CONCLUSIONS

The hypothesis that the relative difficulty of two comparable tasks is determined by the degree of parsimony of the principles used in

their performance and by the perceptual difficulties involved in the application of the principles is adequate for the prediction of the relative difficulty of the eight mazes investigated. As applied to mazes of equal length and number of choices it may be stated: The relative difficulty of two maze patterns composed of spatially equivalent units is determined by the number of changes in procedure necessary for errorless performance and by the perceptual prominence of the cues which indicate where the procedure must be changed.

This principle is not only adequate to explain differences in the number of trials required to run our own mazes but is very well illustrated by the results of Montpellier (5). His mazes in which the correct choice was always to the right, falling under our classification of the most parsimonious principle, were learned in 7.5, 5.6, and 8.0 trials respectively. His maze 1, involving a shift in procedure from simple to double alternation, required more than 15 trials with the most frequent errors occurring in the section where the change in procedure was necessary.

A decreasing incidence of error as the goal was approached in the simple principle maze is cited by Montpellier as evidence for the goal-gradient hypothesis. We would rather regard it as due to the selection by some of the animals of an adequate procedure before the later sections are reached even for the first time. In our LLL-LLLLLLL maze the errors made at the successive sections on the first trial were:

Section	1	2	3	4	5	6	7	8	9	10
Errors	5	2	2	5	2	4	3	0	0	0

There is not only a decrease in the incidence of wrong choices as the goal was approached for the first time, but in the last three sections the correct choice was made on the first attempt by every one of the nine rats in the group. The animals, in exploring the earlier section of the maze, selected procedures which enabled them to make the correct choices in the last three sections the first time these sections were entered. Since these animals had never reached the food-box the phenomenon is not backward elimination or food-box conditioning. It is rather analogous to the forward determination found by Wees (10) in the reproduction of narrative material by school children, in which the function of each successive item of the origi-

nal was limited and defined by the tenor of the preceding items Just as the possibilities of the narrative were increasingly limited and defined by each new item, the possibilities of the maze were narrowed by each successive section until every animal had selected an adequate procedure.

In general, those mazes where the adequate procedure might be based on the general character or principle of the maze were learned much faster than those where the performance must be pertinent to individuated features of the maze

General Conclusions

The results of these experiments, together with those of experiments on human subjects (6), appear to warrant the following conclusions.

1. The diversity of difficulty among mechanically equivalent tasks is concomitant with phenomenological differences among the tasks. Tasks experienced as equivalent are performed with equal facility; tasks experienced as different are performed in different times.

2. The degrees of difficulty of two mechanically equivalent tasks are in the same relation as their experienced complexity The relative speed of learning is determined by the experienced simplicity of the procedures required for performance and by their perceptual practicability.

3. When an individual, rat or human, is confronted with a task, he shows an activity which might be described as the selection of a procedure for its performance.

4 The general procedure he adopts is determined by his initial perception of the nature of the problem; it is a gross response to a relatively undifferentiated situation Problems experienced as similar are attacked by similar procedures In the present investigation, the tasks constructed upon single parsimonious principles, and thus amenable to performance by these immediate responses to the grosser aspects of the problem, were mastered in a fraction of the time required for the learning of tasks whose performance necessitated behavior specific to various segments of the situation.

5. Should the first procedure, the response to the gross situation, prove inadequate, the task is differentiated perceptually into seg-

ments each of which may be solved by simple procedures The greater the number of sub-problems into which the task must be differentiated and the greater the difficulties of this differentiation, the longer will be the time required for mastery

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LA DIFFICULTÉ RELATIVE DES TÂCHES MÉCANIQUEMENT ÉQUIVALENTES· II. L'APPRENTISSAGE ANIMAL

(Résumé)

Dans la première section de cette étude il paraissait que le temps nécessaire à l'exécution d'une tâche a dépendu de la conception de la nature de la tâche par le sujet plus le principe employé a été parsimonieux et plus la *différenciation perceptive essentielle à son application a été manifeste*, plus l'exécution a été efficace

Cette hypothèse s'est montrée satisfaisante pour la prédiction exacte de la difficulté relative chez les rats blancs de huit formes diverses des labyrinthes U de Warden à 10 sections. Les labyrinthes construits selon de simples principes visuels ou spatiaux tels que "vrai parcours toujours blanc" ou "vrai parcours toujours à gauche," lesquels ont été ainsi ouverts à l'exécution par un seul procédé, ont été appris en de 6 à 10 épreuves; en

contraste avec les 34 et 45 épreuves nécessaires à deux groupes pour apprendre le labyrinthe "étalon" de la même longueur et du même nombre de tournants Une autre forme, supposément insoluble par les rats, a été appris par un autre groupe en 6 épreuves quand la prééminence du repère a été augmentée Selon l'expectation, les tâches exigeant deux procédés pour l'exécution ont été d'une difficulté intermédiaire entre les tâches d'un procédé seul et celles de procédés multiples.

SNYGG

DIE RELATIVE SCHWIERIGKEIT DER MECHANISCH GLEICHWERTIGEN AUFGABEN II DAS TIERLERNEN

(Referat)

In dem ersten Teil dieser Untersuchung erschien es, dass die nötige Zeit zur Ausführung einer Aufgabe von der Vorstellung der Person über die Natur der Aufgabe abhängt je sparsamer der gebrauchte Grundsatz und je augenscheinlicher die Wahrnehmungsunterscheidung, die zu dessen Anwendung notwendig ist, desto wirksamer die Leistung

Diese Hypothese zeigte sich hinreichend zum genauen Voraussagen der relativen Schwierigkeit bei weissen Ratten von acht verschiedenen Mustern von zehnteiligen Warden U-Labyrinthen Die Labyrinthe, die nach einfachen Gesichts- oder Raumgrundsätzen gebaut wurden, z.B "der richtige Weg immer weiss" oder "der richtige Weg immer nach links," die auf diese weise der Leistung durch ein einzelnes Verfahren offen waren, wurden in von 6 bis 10 Proben im Gegensatz zu den 34 und 45 Proben bemeistert, die von zwei Gruppen zum Lernen des "Standardlabyrinths" derselben Länge und Anzahl der Biegungen erfordert wurden Ein anderes Muster, das angeblich unlösbar für Ratten ist, wurde in 41 Proben gelernt, wenn eine optische Hilfe in den richtigen Teil des Labyrinths gestellt wurde, und es wurde von einer anderen Gruppe in 6 Proben gelernt, wenn die Sichtbarkeit der Hilfe vermehrt wurde. Als erwartet wurde, lagen die Aufgaben, die zwei Verfahren zur Ausführung erforderten, zwischen einzelnen und vielfachen Verfahrenaufgaben an Schwierigkeit

SNYGG

THE ASSOCIATION VALUE OF THREE-PLACE CONSONANT SYLLABLES*[1]

From the Psychological Laboratories of the Institute of Human Relations, Yale University

LOUISE R. WITMER

This study was an attempt to construct a new material for use in memory experiments, in which the units consist of three consonants each instead of the usual two consonants separated by a vowel. A survey of the list of "consonant syllables," however, showed that there were several units which were meaningful as abbreviations, symbols, or words with the vowels omitted: HCL, BLW, FSH. The first step in the standardization of the material appeared to be the elimination of all meaningful combinations, and this research was an application of Glaze's (5) method to classification of consonant syllables by association value.

Since pronunciation of syllables has commonly been replaced by spelling of the letters (9), consonants offer many possibilities. Over 5000 such combinations can be made, and so the experimenter may compose many test lists without the necessity of repeated items. The absence of a vowel lessens the similarity to words, and the fact that they cannot be pronounced also decreases meaningfulness.

Ebbinghaus, in his classic study, "Memory" (2), introduced the nonsense syllable, which he supposed to be a more homogeneous material than poetry or prose because of its meaninglessness. Nonsense syllables were composed of a vowel or a dipthong between two consonants and were pronounced as a word. He did not attempt to discard the meaningful combinations but claimed that they were very rare, "scarcely a few dozen" in a total list of 2300. Such material was championed at once because it lent itself to a large

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[1]This work was done at the Psychological Laboratories of the Institute of Human Relations and presented to Yale University for the degree of Master of Science. The writer wishes to acknowledge her indebtedness to Dr. E. R. Hilgard for his suggestion of the problem and his criticism and encouragement throughout the investigation.

number of combinations which were thought to be quite comparable and could therefore be measured mathematically.

Almost fifty years have passed since Ebbinghaus made his contribution, but few improvements have been made in the original formula. His assumptions were accepted without experimental proof, and many workers carefully prepared lists of syllables according to definite principles for use in their research. Muller and Schumann (12) composed over 2000 nonsense syllables in German, but they too included the monosyllabic words. Meaningfulness concerned them only when two succeeding syllables in a series made a word or phrase, as, for example, *Weib-lich* or *gib-mir*, and all such sequences were ruled out when the lists were constructed. Gamble (4) made the following comment upon their lists: "In a set of thirty German normal series of eighteen members each, with no syllable duplicated, the writer can find only fifteen German words (2.8 per cent of 540), *including dialect words and all verb forms.*" She constructed a similar list of English syllables and found that 86 were words or slang and 59 more were phonetic spellings, 145 in all or 26.8 per cent.

Kjerstad (7) studied the form of the learning curve with nonsense syllables, digits, and words and found least negative acceleration in the curve for digits. This was explained, he thought, by the fact that digit units are more homogeneous and hence more equal in difficulty, whereas the first syllables to be learned are those which are easiest because meaningful. Some number groups were easy for some individuals because they resembled familiar dates, street numbers, or post box numbers. He also used a few groups of three consonants in his study, and the curve approached that for numbers in that it showed less initial rise.[2] They required more repetitions for learning than either syllables or numbers. The factor of greater difficulty may be deduced from the assumption of less meaningfulness of consonants and that of less negative acceleration from greater homogeneity of the material.

Cason (1) published a list of 300 nonsense syllables from which he had eliminated all those with difficult pronunciation and those

[2]He does not discuss the method of constructing groups of consonants. The data for learning of this material are based on one subject and 12 syllables.

which had been judged meaningful by several "qualified persons" The resultant list was extremely meager, and he still found "about half of the syllables in a large dictionary." By requiring syllables that were easy to pronounce, he omitted much of the best nonsense material

The first experimental attempt to study meaningfulness of nonsense syllables was made by Glaze (5) He prepared all possible combinations of two consonants with a vowel between, using Y both as a vowel and as a consonant. From this group all English words were omitted The remaining list of 2019 syllables was presented tachistoscopically (and spelled by the experimenter) to 15 undergraduate students with instructions to indicate what meaning each had, if any The syllables were classified in 16 groups according to their "association value." Thus, a syllable to which each of the 15 subjects responded was judged to be 100 per cent meaningful, and one which received only seven responses was given 46.7 per cent association value The 0 per cent syllables were those for which no subject reported meaning BAL, DIF, and WIL are examples of meaningful material and GIW, KYH, and TOV of 0 per cent value. There are 101 syllables which have no association value, and those of 50 per cent or less total 1046 The mean of his distribution is 7 48 responses per syllable, or 50 per cent association value, and the sigma 4 53. Though it is obvious that the 16 groups are not reliably different, it is probable that the 93 33 per cent and the 53.33 per cent syllables are reliably different, as are the 46 67 per cent and the 6 62 per cent syllables, because the difference is 2 44 times the standard deviation in both cases

McGeoch (10) compared lists of nonsense syllables of 0 per cent, 20 per cent, 47 per cent, 53 per cent, 73 per cent, and 100 per cent association value for difficulty of learning when studied for periods of 60 and 120 seconds by the method of complete presentation The recall scores showed a positive relation between increase in amounts learned and increase in association value, although there was no distinction between the 47 per cent, 53 per cent, and 73 per cent groups. Three-letter words were found to be less difficult than syllables. In an unpublished study by Melton (11) lists of syllables from Glaze's 0 per cent, 47 per cent, and 100 per cent categories were learned by the anticipation method Ease of learning increased with greater

association value as shown by the number of trials required for mastery and also by the recall scores.

By varying the technique, Hull (6) found important changes in results which were reliably different from those of Glaze. The subjects were instructed to attempt to learn by the anticipation method a list of nonsense syllables which was presented to them three times, pronouncing each syllable as a word while studying it If any syllable brought to mind some association, they were asked to tell the experimenter, but they were cautioned not to search out meanings deliberately Hull's subjects found the material much less meaningful, the average association value by his method is only 21.3 per cent The differentiating factors seem to be (1) the pronunciation of the syllables and (2) the fact that the problem of memorization was uppermost in the subject's mind.

Krueger (8) studied the relative difficulty of 2183 nonsense syllables for 200 people by presenting the material orally to small groups of students. Each item was spelled twice by the experimenter, and the subjects had seven seconds in which to write down any meaning which occurred to them. He arranged the syllables in 200 lists according to the number of responses received Such results point out the fallacy of Ebbinghaus' assumption of the homogeneity of nonsense syllable material.

Series of single consonants have been used successfully by Robinson (13) in a study of retroactive inhibition He presented lists of eight consonants by the memory-span method, in which the first four represented the original list and the second four the interpolated activity of the conventional experiment Degrees of similarity were adjusted by varying the number of letters common to both series. With other methods of learning (for example, anticipation or reproduction of the material learned) that require long lists or large numbers of units, single letters, like digits, must be repeated too frequently. By using groups of three or more consonants the number of items is tremendously increased

Technique

Since consonant syllables are to be used in investigations of memory, a test of their meaningfulness should duplicate as far as possible the methodology of such experiments The technique em-

ployed by Luh (9) was chosen as a guide because his methods are generally accepted for such work His apparatus was a rotating drum on which typewritten lists of nonsense syllables were affixed so that one unit would be exposed at a time Finkenbinder's (3) anticipation method was employed, and the subjects were instructed to spell each syllable aloud letter by letter The time of exposure for each item was two seconds. This problem of the time interval has been a difficult one, and investigators are not yet agreed as to the relative merits of shorter and longer exposures Since subjects are usually instructed to attend to the syllable at hand and not to attempt to rehearse the list, a two-second interval is commonly used Thus, the apparatus, the method of presentation, the time interval, and the spelling of letters are the important features to be paralleled

The apparatus for this experiment was a rotating memory drum modified by the addition of a second cylinder some distance behind the drum to permit the use of long bands of material, so that they would not have to be changed during one sitting The drum was turned mechanically by a constant speed motor. A small aperture in the screen which covered the drum permitted the subject to see one syllable at a time and could be adjusted horizontally by the experimenter. The letters were typed on heavy white paper in Gothic capitals 4 by 6 mm in size. Conditions of illumination were kept constant by the use of electric light rather than daylight

The material included all possible combinations of three consonants, subject to certain restrictions. Besides the vowels, the letters Y and V were also omitted, the former because it is sometimes used as a vowel and the latter because it resembles the old English U and might therefore be given a vowel sound. This leaves 19 consonants with which to work. The same letter was never used twice in one syllable nor were two letters which occur next to each other in the alphabet There were 4534 consonant syllables in the final list The lists for the experiment were arranged so that the same letter was not repeated twice in three succeeding syllables nor given the same position in four

Each syllable was exposed for four seconds[3] This long interval

[3]Glaze allowed a maximum of 3 seconds, but if the subject responded before that time the next syllable was presented immediately The movement of his drum was made by hand, and he says that the "minimum time was not less than 2 seconds"

was chosen for two reasons. First, in a preliminary study in which the subjects were not required to respond within a limited time but could take as much or as little time for each unit as they wished, the average time per syllable was 4.2 seconds Secondly, in memory experiments the list to be learned is presented several times so that associations might occur on a later repetition, and hence it seemed advisable to use a four-second interval The material was divided among six sittings, each of which lasted about an hour and included two rest periods. These six sections of the material were counterbalanced, as were smaller divisions within the hour periods Two experimental periods never occurred on the same day, and more than one day sometimes intervened

Subjects were instructed to watch the aperture and to spell the syllable aloud letter by letter as soon as it appeared, because it was suspected (and later proved by results) that the sound of the letters might suggest associations which would not occur simply from their appearance.[4] They were then to state in a word or phrase what the letters meant to them, if anything. If the syllable seemed familiar, but its meaning could not be stated quickly enough or could not be recalled, it was permissible to say, "Yes." If the syllable had no meaning, no response was necessary. Subjects were told that the experiment was in no sense a test of their abilities, and that it was not necessary to force an association for each letter group In spite of this caution, several subjects admittedly "made a game" of finding some response for every item, no matter how distant the association The writer acted as experimenter and wrote down the responses exactly as they were given. A preliminary trial was given in which each subject was shown a list of fifteen common three-letter abbreviations, words, and meaningful groups, none of which were to be found in the experimental material

The subjects were 24 men, of whom 15 were undergraduates of Yale College or the Sheffield Scientific School and had never participated in memory experiments Of the remaining nine, two were instructors and the others graduate students in the Department of Psychology of Yale University By using more subjects than Glaze (15) it was hoped to secure more reliable differences between degrees

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[4]Glaze spelled the syllables aloud for his subjects The above change was made because it more nearly approximates the learning situation

of meaningfulness of the data All subjects were given the Higher Form of the Otis Self-Administering Intelligence Test and the Binet-Simon vocabulary test The intelligence scores fell in the upper 25 per cent of college norms with extreme crowding at the upper limit of the scale. Vocabulary scores ranged from 13,000 to 18,000 words with the average at 16,000. The ages of the subjects were distributed fairly normally from 17 to 29 years

RESULTS

The first step in treatment of the data involves classification of the syllables according to the number of responses given to each, thus making 25 lists of syllables ranging from zero to 24 responses, or, using Glaze's terminology, from 0 per cent to 100 per cent association values. The 24 subjects gave a total of 47,102 responses Only 11 of the syllables had no meaning for any individual and ten were meaningful for everyone Between these extremes are found all degrees of association value in a distribution definitely skewed in a positive direction The average number of responses per syllable is 10 39 and the sigma of the distribution is 3 77. The mean for Glaze's syllables is 7 48 responses and the sigma 4.53. In other words, an hypothetical average nonsense syllable has an association value of 50 per cent whereas the consonant syllable has an average

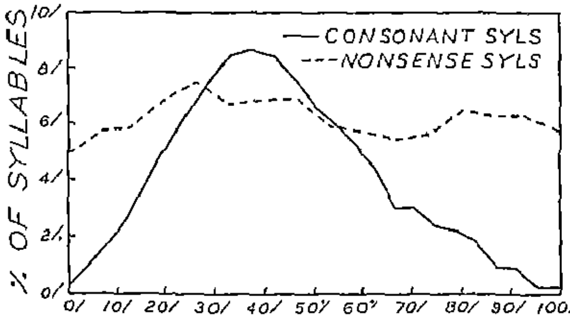

FIGURE 1

CONSONANT SYLLABLES COMPARED WITH NONSENSE SYLLABLES FOR MEANINGFULNESS

The curve for nonsense syllables was drawn from data presented by Glaze

association value of 43 per cent. Since the latter are more than twice as numerous as the former, only those of 50 per cent meaningfulness or less may be used and a conveniently large number still remain (3138). Such treatment cuts the mean association value to 29 per cent. Figure 1 shows the distribution of Glaze's nonsense syllables and consonant syllables with respect to meaningfulness.

A more minute division of the responses may be made by classifying them in terms of their association with one, two, or three letters of the syllable, since meaning gives unity and therefore ease of learning to the group. Responses which were associated with the only one letter of the syllable were ignored in both this and the above classifications Those remaining were divided according to two- or three-letter associations. For example, DSK (desk) is a three-letter response whereas XPS (postscript) and KFN (fan) are two-letter associations. Glaze does not mention this problem of partial associations specifically, and if they do not occur with nonsense syllables this may indicate a fundamental difference between the two materials. He does, however, describe one subject who "seemed to pronounce any word that came to mind, which, by the greatest stretch of the imagination, could be only remotely associated with the syllable in many instances" In the case of the nonsense syllable the combination of a vowel and consonants gives it the form of a word even though meaningless, but three consonants do not occur often as a unit, especially in the English language, and are therefore more likely to be broken up into two-letter groups Fifty-nine per cent or over half of the total number of responses were associated with only two letters. Such classification is of necessity a subjective one, for the experimenter cannot always be sure of what the subject had in mind when a word was given In general, all correct, phonetic, and reversed spellings with the three letters are included in three-letter responses, and that group is the preferred classification in doubtful cases

The two-letter responses are of two kinds, abbreviations, and words formed by combining two of the consonants with other letters The first class contains MSJ (manuscript, MS) and KMD (doctor, MD), while the second is composed largely of monosyllables like ZND (Ned) and QDL (dell).

Figure 2 presents the comparative distribution of these two kinds

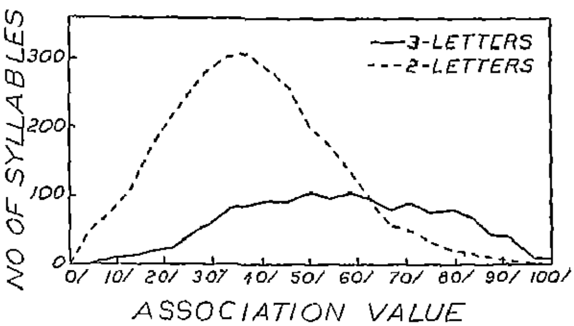

FIGURE 2

DISTRIBUTION OF THREE-LETTER AND TWO-LETTER RESPONSES FOR SYLLABLES OF EACH ASSOCIATION VALUE ABOVE ZERO

of responses It is interesting to note that the means of the two-letter and three-letter responses are quite distinct (8.99 and 13.50 responses respectively). Apparently those syllables which are high in association value received very few two-letter responses, but when the subjects could find no three-letter responses they fell back on partial associations The distribution for three-letter responses approaches the normal curve with slight negative skewness, and the two-letter curve is more noticeably skewed in a positive direction.

A tabulation based on a random sample of 776 syllables showed that 27 per cent (from all degrees of association value) received

TABLE 1

TYPES OF ASSOCIATIONS AND THEIR DISTRIBUTION*

		Per cent
1	Words formed by adding letters	43.7
2	Two-letter associations	31.6
3.	*Pronunciation (phonetic spelling)*	12.2
4	Personal references (including famous people as well as family and friends)	5.6
5.	Geometric form	2.9
6	Initials, symbols, abbreviations	2.9
7	Sound of letters	0.7
8	Foreign words	0.5
	Total	100.1

*The author has no data on the total mass of material for these qualitative distinctions, but a preliminary study with coarser techniques yielded the above results for five subjects and 2408 syllables The figures are representative of the total if not exact

"Yes" responses, however, only 3 per cent received more than one such response and no syllable was given more than three. These replies were excluded in determining the meaningfulness of the syllables

There are several classes of responses which are qualitatively different. A very large percentage of the meaningful syllables are those which form words when letters are added—WHP, DNT, FRM (whip, don't, from) Another group, few in number but high in association value, is composed of initials of famous people, abbreviations, and symbols—GBS (G B. Shaw), RPM (revolutions per minute), and CMT (Citizen's Military Training Corps). Some subjects are inclined to substitute letters of similar geometric form, such as O for Q, C, and G, and E for F—LQT (lot) and BFN (Ben). The style of printing used was extremely simple and consequently the differentiation of these letters by "curlicues" and other common decorative lines was lacking. There are a few syllables which sound familiar when spelled letter by letter—LCT (Elsie) and KCT (Casey). Another large group of responses are prompted by phonetic spelling—QWD (quid), FCS (fix), and PHR (for). Most subjects gave a small percentage of personal initials, but these were not included in the computation of association values because they have no general significance Undoubtedly this is one source of error in the material. There are also a few responses gained by reversing letters—HTM (them) and TLB (table).

Differences between the number of associations found by individual subjects are very marked Some responded only to those which were obviously meaningful, and others attempted to find some association, no matter how far-fetched, for every group of letters. It is in this latter group that most of the two-letter responses are found, as well as those concerned with only one letter, which, as has already been stated, were not included in the scoring. Two subjects gave no partial responses whatever, and when questioned at the end of the experiment one said he had consciously excluded all associations which did not fit the syllable as a unit; the other stated that no such responses occurred to him. There is no correlation between the number of responses and the intelligence and vocabulary of the subjects. There might have been less variation if the in-

structions had explicitly required associations to a part of the syllable as well as to the entire unit The practice list included no syllables in which only two of the letters were meaningful. Both of these methods were rejected because the experimenter did not wish to suggest associations or methods of looking for them Finally, such individual differences do not invalidate the experimental results because they remain constant throughout the entire list In all probability these forced associations would be infrequent in a memory experiment where attention is directed to a different task and the subjects are warned to avoid mnemonic aids to learning The variations in the results of Hull and Glaze have been attributed in part to the modified technique of the former. In the experiment here reported, as in that of Glaze, the subjects were looking for meaning. Also, experienced subjects soon train themselves to avoid associations

The reliability of the difference between syllables of any two association values may be computed by the formulas for the standard error of a proportion and of a difference

$$\sigma_p = \sqrt{\frac{pq}{n}} \qquad\qquad \sigma_{diff} = \sqrt{\sigma_{p_1}{}^2 + \sigma_{p_2}{}^2}$$

The sigma of the proportion (the percentage of association value of any group of syllables) is equal to the square root of the percentage of responses (p) times the percentage not responding ($q = 100 - p$), divided by the number of cases—24 possible responses. The reliability of the difference between any desired pair of association values may be found in Table 2 in terms of the critical ratio between their obtained difference and the sigma of their difference. Any ratio over 3.0 is considered significant If it is desired to have two lists reliably different they should be chosen so that nine degrees of association value intervene or so that they differ by 37.5 per cent association value This is the minimum estimate for lists near the 50 per cent point However, reliability increases as one approaches the ends of the scale so that 0 per cent and 29 17 per cent syllables are reliably different, also 75 per cent and 100 per cent. At the limits of the distribution it will be necessary to combine several groups in order to have a working number of syllables In this case the average association values must be determined and their critical ratios found in the table

TABLE 2

CRITICAL RATIOS OF DIFFERENCES IN ASSOCIATION VALUE

Association value—per cent	Association value—per cent 0 00	4 17	8 33	12 50	16 67	20 83	25 00	29.17	33 33	37 50	41 67	45 83	50 00	Association value—per cent
0 00	0.0	1 0	1 5	1 9	2 2	2 5	2 9	3 2	3 5	3 8	4 2	4 6	5 0	100 00
4 17	1 0	0 0	0 6	1 0	1 5	1 8	2 2	2 5	2 8	3 2	3 5	3 9	4 2	95 83
8.33	1.5	0 6	0 0	0 5	0 9	1 3	1.6	1 9	2 3	2 6	2 9	3.3	3 6	91 67
12 50	1 9	1 0	0 5	0 0	0 4	0 8	1 1	1 5	1 8	2 1	2 4	2 7	3 1	87 50
16 67	2 2	1 5	0 9	0 4	0 0	0 4	0 7	1 1	1 4	1 7	2 0	2.3	2 7	83 33
20 83	2 5	1 8	1 3	0 8	0 4	0 0	0 3	0 7	1 0	1 3	1 6	1 9	2 2	79 17
25 00	2 9	2 2	1 6	1 1	0 7	0 3	0 0	0 3	0 7	1 0	1 3	1 6	1 9	75 00
29 17	3 2	2 5	1 9	1 5	1 1	0 7	0 3	0 0	0.3	0 6	0 9	1 2	1 5	70 83
33 33	3 5	2 8	2 3	1 8	1 4	1.0	0 6	0 3	0 0	0 3	0 6	0 9	1 2	66 67
37.50	3 8	3.2	2 6	2 1	1.7	1 3	1 0	0 6	0 3	0.0	0 3	0 6	0 9	62 50
41 67	4 2	3 5	2 9	2 4	2 0	1 6	1 3	0 9	0 6	0 3	0 0	0 3	0 6	58 33
45 83	4 6	3 9	3 3	2 7	2 3	1 9	1 6	1 2	0 9	0 6	0 3	0 0	0 3	54 17
50 00	5 0	4 2	3 6	3 1	2 7	2 2	1 9	1 5	1 2	0 9	0 6	0 3	0 0	50 00
54 17	5.2	4 6	4.0	3.5	3 0	2 6	2.2	1 8	1 5	1 2	0 9	0 6	0 3	45 83
58 33	5 9	5 1	4 4	3.8	3 3	2 9	2 5	2 2	1.8	1 5	1 2	0 9	0 6	41 67
62 50	6 4	5 5	4 8	4 2	3 7	3 3	2 9	2 5	2 1	1 8	1 5	1 2	0 9	37 50
66 67	7 0	6 1	5 3	4 7	4 1	3 7	3 2	2 8	2 5	2 1	1 8	1 5	1 2	33 33
70 83	7 7	6 7	5 8	5 2	4 6	4 1	3 6	3 2	2 8	2 5	2 2	1 8	1 5	29 17
75 00	8 6	7 4	6 4	5 7	5 1	4.5	4 1	3 6	3 2	2 9	2 5	2 2	1 9	25 00
79.17	9 7	8 2	7.2	6 3	5 6	5.2	4 5	4 1	3 7	3 3	2 9	2 6	2 2	20 83
83 33	11 1	9 4	8 0	7 1	6 3	5 6	5 1	4 6	4 1	3 7	3 3	3 0	2 7	16 67
87 50	13 1	10 7	9 1	8 0	7 0	6 3	5 7	5 2	4 7	4 2	3 8	3 5	3 1	12 50
91 67	16 5	12 7	10 6	9 1	8.0	7.2	6 4	5 8	5.3	4 8	4 4	4 0	3 6	8 33
95 83	23 8	16 1	12 7	10 7	9.4	8 2	7 4	6 7	6.1	5 5	5 1	4 6	4.2	4 17
100 00	∞	23 8	16 5	13 1	11 1	9 7	8.6	7 7	7 0	6 4	5 9	5 2	5 0	0 00
	Association value—per cent 100 00	95 83	91 67	87 50	83 33	79 17	75 00	70 83	66 67	62 50	58 33	54 17	50 00	

A critical ratio of two values is defined as the difference between them divided by the sigma of their difference A ratio of 3 0 or more is generally considered reliable In this table the upper values are to be read with the left hand column, the lower values with the right hand, thus: the difference (37 50 per cent) between 8.33 per cent and 45 83 per cent association value is 3 3 times the sigma of their difference The ratio between 54 17 per cent and 91 67 per cent is also 3.3.

Summary

1. Twenty-four subjects were asked to give the meaning, if any, of 4534 three-place consonant syllables, which were presented singly on a memory drum for four seconds each. The association value of each syllable was determined on the basis of the percentage of responses Those which were judged meaningful by all subjects were said to have 100 per cent association value, and those to which no subject responded were grouped at 0 per cent with all the intervening possibilities scaled between these limits The mean association value is 43 per cent and the sigma 16 per cent. The distribution is positively skewed The syllables are listed in Table 3.

2 There were more associations to two than to three of the letters, but such responses were more common to the relatively meaningless items. In other words, they represent a failure on the part of the subject to find meaning in the entire item

3 A comparison of consonant syllables with nonsense syllables as classified by Glaze shows that the two types of material have very different distributions His syllables are almost evenly divided into 16 groups of meaningfulness, while consonant syllables more closely approach the normal curve

4 The individual variations in total number of responses were found to have no correlation with intelligence or size of vocabulary, as measured by the Otis Self-Administering Intelligence Test and the Binet-Simon Vocabulary Test for superior adults.

5. A difference of 37.5 per cent association is the maximum required for reliably different groups Critical ratios between all pairs of association values have been computed and presented

6 The advantages of this material as a supplement to the usual nonsense syllables are:

a 4534 units are available

b. The material is less meaningful than nonsense syllables Its mean association value is 43 per cent as against 50 per cent for nonsense syllables.

c. There are 3138 consonant syllables with an association value of not more than 50 per cent, this group is still larger than the total number of nonsense syllables and the mean association value has now

TABLE 3
ASSOCIATION VALUE OF CONSONANT SYLLABLES

0% 11	4% 48	8% 84		13% 127			17% 184			
QJF	BQJ	BHJ	WBH	BPJ	QCZ	XZK	BFM	JQW	QLB	XQN
QJH	CXJ	BJH	WBJ	BQF	QDJ	XZL	BJQ	JSB	QLN	XSB
XFQ	DJX	CJQ	WBQ	CFJ	QFX	ZBF	BMF	JTQ	QWB	XSG
XJQ	FHJ	CJX	WFC	CFQ	QFZ	ZBG	BQZ	JXH	QXG	XTD
XZF	GCJ	CQH	XBJ	CGJ	QGC	ZBH	BWF	JZF	QXZ	XZG
ZGJ	GJQ	CXQ	XDH	CGP	QHF	ZBQ	CJZ	KBH	QZK	XZM
ZJF	GJX	DHJ	XFH	CGQ	QJS	ZCQ	CQZ	KBP	RBM	ZDJ
ZJQ	GQC	DJB	XFS	CJH	QMW	ZDH	CSF	KFX	RJX	ZDL
ZQJ	GQJ	DJQ	XGC	CQJ	QWJ	ZDW	CWH	KHB	SBH	ZFH
ZXJ	CQX	FCJ	XGQ	CXK	QXF	ZFC	CXF	KHF	SGJ	ZFM
ZXQ	GXK	FJH	XHF	DJW	QXH	ZFW	CXH	KHQ	SJH	ZFX
	GXM	FJQ	XHJ	DJZ	QXL	ZHK	CXZ	KQM	SXH	ZGB
	HFC	FQW	XHM	DXJ	QZB	ZHX	CZJ	KQW	TCZ	ZGQ
	JFH	FQH	XJH	FHC	QZH	ZKG	DJH	KWQ	TGJ	ZJB
	KHX	FXQ	XQG	FPC	QZJ	ZKH	DJS	KXN	TJF	ZJL
	KQF	GCQ	XZD	FPW	QZM	ZLC	DQH	KXR	TJQ	ZJN
	KQX	GJC	XZJ	FQC	SBQ	ZMC	DWB	KZX	TZW	ZJW
	KXB	GQB	ZCJ	FQJ	SBZ	ZMX	FCQ	LJF	TZX	ZKB
	MHZ	GXC	ZCX	GCX	SJF	ZQC	FJC	LJX	WBN	ZKX
	MZJ	GXQ	ZFK	GCZ	SZJ	ZQG	FJS	MBH	WCJ	ZLJ
	QGJ	HBJ	ZGW	GKX	TFJ	ZQH	FJW	MBW	WCZ	ZLQ
	QHJ	HFK	ZHW	GQK	TFQ	ZQS	FPJ	MBX	WGP	ZMF
	QXB	HJC	ZJC	GXJ	TJW	ZTF	FQK	MGQ	WJH	ZMJ
	QXJ	JFQ	ZJT	HCJ	TZF	ZTJ	FWJ	MHF	WQB	ZMW
	QXN	JQF	ZJX	HJX	TZQ	ZTX	FWQ	MQB	WZC	ZNW
	XBQ	JXF	ZQX	HKM	WBF	ZWJ	GKQ	MWF	XBD	ZPB
	XFJ	JXQ	ZSJ	HXF	WCF	ZXG	GKZ	MWZ	XBH	ZQL
	XJB	KFQ	ZSQ	JCF	WCQ		GXZ	MZQ	XBM	ZRJ
	XJF	KQB	ZTK	JFC	WQH		GZB	NCF	XBZ	ZSF
	XKH	KQH	ZWQ	JFN	WZQ		GZK	NFB	XCZ	ZTW
	XMJ	KQZ	ZXC	JQZ	XBF		GZQ	NPB	XDF	ZWC
	XQF	KXC	ZXH	JXB	XBN		HBM	NQF	XDL	ZWF
	XQH	KXD	ZXK	JZH	XCJ		HCZ	NQS	XFC	ZXD
	XQJ	KXH	ZXR	KBF	XDJ		HFJ	NQX	XFM	ZXL
	XQL	MHJ		KFZ	XFK		HFM	NZK	XGJ	
	XTJ	MHW		KMF	XFP		HJF	PJF	XHC	
	XZQ	MJF		KXQ	XFZ		HWC	PJZ	XHQ	
	ZBJ	MWB		KXZ	XGK		HXB	PXB	XJL	
	ZFJ	MZB		KZF	XGP		HXJ	PXH	XJP	
	ZFQ	QCF		KZG	XGZ		HXQ	PZW	XJS	
	ZGX	QDX		KZH	XJC		HZW	QCJ	XJZ	
	ZHJ	QFC		KZS	XKB		JBP	QCM	XKF	
	ZJH	QFH		LCF	XKQ		JDF	QFJ	XKG	
	ZQB	QGW		LHJ	XNZ		JDH	QFK	XKR	
	ZQF	QGX		MCF	XMZ		JDW	QFS	XKZ	
	ZQW	QHN		MFH	XQB		JFM	QHX	XLJ	
	ZXB	QJC		MHB	XQD		JHC	QJB	XLZ	
	ZXF	QLJ		MQJ	XSZ		JHF	QJM	XNJ	
		QSJ		MWJ	XTG		JHW	QJW	XNQ	
		TZH		QBJ	XZC		JQH	QJX	XQM	

TABLE 3 (*Continued*)

21% 241					25% 292					
BFJ	HBF	MBQ	RWH	XRH	BFP	FXK	JCZ	NDJ	RJL	XKD
BFQ	HBX	MCJ	RWJ	XRJ	BFX	FXZ	JDT	NFC	RJP	XLC
BFZ	HJL	MFB	RXF	XSJ	BGQ	FZB	JFW	NFJ	RMF	XLG
BJS	HJQ	MFP	RZJ	XTF	BJG	FZH	JGQ	NFL	RMJ	XLH
BQD	HJW	MFX	SFJ	XZB	BJW	FZM	JHB	NFX	RWF	XLR
BQH	HKB	MJW	SFM	XZH	BJX	FZW	JQX	NKR	SBG	XMB
BTP	HWB	MWQ	SJZ	XZN	BMJ	GBQ	JSW	NLX	SBX	XMF
BWJ	HWF	MZC	SZK	XZS	BPX	GCM	JTB	NQG	SDH	XMH
BWQ	HWQ	NFQ	TCF	ZBX	BXF	GCS	JTW	NWL	SFH	XMQ
BXP	HWZ	NLQ	TCJ	ZCF	BXH	GDQ	JWB	NXQ	SFP	XNP
BZJ	HZC	NQJ	TFM	ZCP	BXJ	GJZ	JWM	NZG	SGC	XQS
BZQ	HZF	NQK	TFW	ZCW	BXZ	GJS	JWP	NZR	SGW	XSF
CFP	HZQ	NKQ	TFZ	ZDF	BZP	GKB	JWQ	PBF	SGZ	XTQ
CFX	JBW	NZX	TJB	ZDG	BZW	GKD	JZN	PJH	SHJ	XZP
CJF	JCM	PBJ	TJH	ZFB	BZX	GKM	JZP	PMW	SJQ	XZR
CJS	JCW	PCJ	TJZ	ZFN	CFZ	GKW	KCF	PWJ	SJW	XZT
CJW	JFS	PJX	TLF	ZFP	CGW	GMJ	KDB	PWZ	SZB	ZBP
CSJ	JFX	PXF	TLN	ZFS	CGZ	GMK	KDH	PZF	SZH	ZBW
CXP	JFZ	PXJ	TQF	ZGC	CJG	GNB	KDQ	PZH	SZQ	ZCG
DBJ	JGC	PXZ	TZJ	ZGK	CKM	GNC	KFC	PZJ	TFH	ZCS
DHX	JGP	PZB	WBK	ZHC	CMJ	GPJ	KFM	PZK	TFP	ZDB
DJF	JHX	QBF	WBM	ZHF	CPJ	GQZ	KFN	QBW	TFX	ZDT
DJL	JLC	QBN	WDB	ZHL	CWF	GWB	KGX	QBX	TJL	ZDX
DLZ	JQC	QDH	WFB	ZJD	CWJ	GWQ	KHZ	QCH	TJX	ZFL
DXK	JQD	QDM	WFQ	ZJP	CWQ	GXT	KSF	QCN	TKZ	ZGP
FBJ	JQS	QFM	WGC	ZJS	CXS	GZJ	KSX	QCS	TQJ	ZHB
FBM	JWF	QFN	WGJ	ZKM	CZG	HCF	KSZ	QCW	TQM	ZHQ
FBX	JXL	QFW	WJQ	ZKN	CZQ	HCX	KTB	QDF	TZG	ZJG
FCM	KBQ	QGD	WLJ	ZKQ	CZT	HFP	KWF	QDG	TZK	ZJM
FHW	KBW	QGK	WPJ	ZLG	DBX	HFQ	KXP	QDK	WBP	ZKF
FJP	KFH	QGZ	WQC	ZLR	DFZ	HFZ	KZC	QDL	WBT	ZLB
FPH	KFS	QHD	WQF	ZLW	DHL	HJB	LDH	QDN	WDK	ZLS
FPN	KHC	QHL	WQJ	ZMQ	DHW	HJN	LFJ	QGL	WFH	ZLX
FQS	KMH	QHW	WQL	ZPF	DKQ	HJS	LJC	QHC	WJF	ZMK
FQZ	KMQ	QJZ	WSF	ZQD	DLF	HJT	LJD	QJG	WJL	ZNB
FSJ	KQC	QKB	WSZ	ZQK	DLX	HKQ	LQJ	QJN	WJM	ZNQ
FXB	KXF	QKH	WZG	ZSB	DQL	HKW	LRP	QKZ	WQZ	ZPG
FZJ	KZB	QKX	WZH	ZSG	DZF	HKZ	LXJ	QLH	WTK	ZPX
FZK	KZQ	QLX	XBK	ZTD	FHK	HMC	LZJ	QMF	WZM	ZWB
FZP	LCP	QMK	XCF	ZTQ	FHQ	HNQ	MBF	QMJ	WZP	ZXM
FZQ	LCZ	QWG	XCG	ZXS	FHX	HXL	MFJ	QMX	XBP	ZXP
GJW	LJB	QXM	XDZ		FJM	HXZ	MKR	QSF	XCQ	ZXT
GKN	LJH	QXS	XHZ		FJZ	HZB	MQD	QSL	XCS	
GQN	LJQ	QZF	XJM		FKP	JBG	MQF	QSW	XDB	
GQW	LJS	QZW	XMC		FKQ	JBH	MQZ	QSX	XDM	
GSQ	LJW	QZX	XMG		FKZ	JBN	MWC	QWF	XFB	
GSZ	LNP	RCJ	XNB		FNX	JBQ	MZF	QZL	XHK	
GWZ	LSF	RJW	XNF		FPB	JBX	MZW	RGW	XHN	
GZN	LZQ	RKH	XQC		FPX	JCN	NCQ	RHK	XJG	
GZW	MBJ	RLJ	XQK		FXJ	JCQ	NCW	RJF	XJT	

TABLE 3 (*Continued*)

			29% 339					33% 384		
BDF	FDK	HXK	KZD	NXL	RZX	XJD	BDH	DKH	HFB	KCG
BHW	FJB	HXN	KZM	NXR	SBM	XJN	BFH	DLB	HFW	KCX
BHX	FKB	HXR	KZN	PBZ	SBP	XKM	BFN	DMX	HJD	KDT
BHZ	FKC	HZK	KZW	PFH	SDB	XKN	BFW	DQJ	HJM	KDW
BJF	FKH	JFP	LBJ	PFJ	SGB	XLN	BGP	DQS	HJP	KFP
BJP	FKM	JHL	LBW	PFZ	SGQ	XLQ	BHF	DQW	HKF	KGP
BMW	FKW	JHQ	LCJ	PGW	SJB	XPJ	BJM	DSW	HKR	KGQ
BPN	FKX	JLH	LDB	PJC	SJG	XQZ	BMG	DWJ	HLC	KHD
BPW	FMH	JLQ	LDF	PJL	SZC	XTL	BMH	DXB	HLJ	KHM
BPZ	FMJ	JLX	LFP	PJW	SZF	XTN	BMX	DXF	HLQ	KMT
BWP	FMQ	JLZ	LGP	PSX	SZG	ZCM	BMZ	DXH	HMJ	KMW
BXK	FMX	JMC	LHB	PXC	SZM	ZCN	BPF	DXL	HSZ	KMX
BXM	FMZ	JMF	LHN	PZC	SZX	ZDP	BQL	DZJ	HWN	KMZ
BZF	FPM	JMH	LHX	PZX	TDH	ZDQ	BWZ	DZQ	HXP	KRH
CFH	FPZ	JNF	LJG	QBM	TFC	ZGS	BZG	FBQ	HZJ	KSN
CFM	FQD	JPF	LRH	QBZ	TJC	ZHM	BZH	FCH	HZP	KSQ
CGK	FQM	JQB	LSJ	QCG	TKF	ZKC	CFL	FCW	HZT	KTM
CKH	FSQ	JQN	LWG	QDB	TLJ	ZKD	CFS	FDQ	HZX	KTW
CKN	FWB	JSF	LWH	QFD	TQB	ZKS	CFW	FHZ	JBF	KWC
CKQ	FWP	JSG	LXP	QGB	TQZ	ZLH	CGX	FJX	JBT	KWG
CNQ	FXH	JSQ	LZC	QGT	TWB	ZMG	CJM	FKS	JBZ	KXM
CPX	FXM	JTF	LZH	QHB	TZB	ZMH	CJN	FMK	JCG	KZP
CQF	GBJ	JTH	MBT	QHK	WBG	ZNF	CKF	FMW	JCH	LBF
CQW	GCK	JWC	MBZ	QJL	WCM	ZPC	CMH	FNQ	JCR	LBZ
CSZ	GCN	JWH	MCG	QKF	WCP	ZPJ	CMZ	FQL	JDL	LCS
CTJ	GCW	JXD	MCQ	QKM	WCS	ZPW	CNP	FQN	JFB	LDJ
CWZ	GJB	JXG	MCW	QLG	WDQ	ZQM	CPF	FSZ	JFD	LDP
CXG	GJL	JXR	MFC	QLW	WFM	ZQN	CPG	FWC	JGB	LDX
CXM	GPN	JXZ	MFW	QMB	WFZ	ZRF	CPM	FWH	JGT	LHC
CZF	GPW	JZC	MGJ	QMG	WGB	ZSW	CPZ	FWZ	JGW	LHD
CZH	GQL	JZQ	MHC	QMH	WGQ	ZTB	CQN	FXP	JLB	LHF
CZL	GQS	JZS	MJZ	QNF	WHB	ZTC	CQX	FZC	JLF	LHW
CZX	GSJ	JZW	MKF	QNW	WHJ	ZTG	CSQ	GBM	JWM	LJP
DFJ	GSM	KBX	MZP	QSB	WJC	ZTL	CSW	GDW	JNB	LJT
DJG	GSW	KCM	MZX	QZG	WJG	ZTM	CSX	GKP	JNW	LJZ
DJM	GXB	KCQ	NCP	RGJ	WJP	ZWH	CXL	GKR	JPC	LNF
DLH	GZC	KDF	NDB	RHF	WLQ	ZWP	CXR	GKT	JQG	LPB
DLJ	HBN	KFW	NDW	RHJ	WQG	ZWS	CZP	GMX	JQL	LPF
DLQ	HCQ	KGC	NFP	RJB	WSG	ZXN	CZW	GNP	JQM	LRB
DQF	HFS	KMC	NKB	RJM	WSJ		DBF	GNQ	JRL	LRJ
DQK	HJZ	KPW	NKF	RLB	WZB		DBG	GNX	JRP	LSZ
DXG	HKP	KQD	NKZ	RLW	WZL		DBQ	GPZ	JSC	LXB
DXP	HKX	KQN	NLC	RMC	WZN		DBW	GQM	JTL	LXH
DZH	HNF	KQS	NLP	RWC	WZS		DFQ	GTD	JWZ	LZX
FBH	HNP	KSB	NPC	RWZ	XCM		DFW	GWC	JXN	MBD
FBP	HNX	KTQ	NQH	RXB	XCP		DFX	GXN	JZM	MBG
FBZ	HQX	KWB	NQW	RXC	XDP		DHK	HBP	JZT	MBK
FCK	HTJ	KWZ	NQZ	RXT	XDQ		DHQ	HBZ	JZX	MFQ
FCZ	HWJ	KXG	NXF	RXZ	XGD		DHZ	HCW	KBG	MFZ
FDB	HXC	KXS	NXJ	RZC	XHB		DJN	HDM	KBM	MGB

TABLE 3 (*Continued*)

33% con				38% 391						
MJB	PXL	SQZ	WTP	BDJ	DWL	HMF	KBS	MGW	QBK	TGW
MJH	PZT	SXZ	WZK	BDK	DXQ	HMW	KCW	MHX	QCX	THL
MJT	QDW	SZP	WZT	BGZ	DZB	HNB	KCZ	MJQ	QDS	TJM
MJX	QDZ	SZW	XBL	BHL	FBT	HNJ	KDZ	MPB	QFL	TKH
MQC	QFB	TDF	XCK	BHQ	FBW	HNW	KGB	MPF	QGM	TNF
MQG	QGN	TDJ	XCN	BJD	FCP	HQL	KHP	MWH	QKD	TNL
MQH	QGS	TDQ	XDN	BNP	FDH	HQZ	KHR	MXJ	QSD	TQC
MQK	QJD	TFB	XDS	BNW	FDP	HSF	KHS	MXZ	QSN	TQD
MQW	QKC	TFK	XGB	BPM	FDX	HSN	KHW	MZG	QTX	TQK
MQX	QLC	TGB	XGL	BQG	FHD	HTB	KNZ	MZK	QWD	TQL
MWP	QLF	TGP	XHD	BQN	FHM	HWP	KQG	NBH	QWZ	TWF
MXB	QLZ	TGZ	XLP	BQW	FHP	HWR	KPB	NBP	QXK	TWJ
NCH	QMZ	TJD	XNL	BSF	FJT	HXD	KQT	NDT	QZD	TWZ
NDP	QNL	TJG	XPB	BSJ	FMC	HXT	KRZ	NGB	RBF	TZM
NDQ	QSG	TJP	XPH	BSX	FNP	HZN	KSW	NGJ	RBJ	TZP
NDT	QSM	TKD	XRL	BTQ	FPR	JBL	KTF	NKW	RBX	WCG
NFK	QWS	TLH	XRP	BWH	FSB	JCL	KTP	NLB	RCW	WDM
NFS	QXC	TLQ	XSD	BZK	FSP	JCP	KTX	NPJ	RFH	WDP
NGK	QXD	TLZ	XTZ	BZS	FSW	JCS	KWR	NPW	RFK	WFK
NJH	QZC	TMF	ZBK	CFK	FWM	JCX	KXT	NPZ	RGP	WFP
NJW	RBH	TNB	ZDM	CGM	GBP	JDQ	KZT	NRZ	RGX	WJB
NKC	RBW	TNW	ZBT	CHJ	GJD	JGX	LBP	NSF	RGZ	WJT
NLF	RBZ	TQH	ZHD	CJT	GJM	JGZ	LBQ	NSQ	RHW	WLB
NLJ	RCG	TQW	ZKP	CKZ	GKC	JHD	LBT	NWC	RLP	WLG
NLR	RCZ	TWH	ZKT	CMQ	GKS	JHM	LBX	NWQ	RTF	WLR
NPF	RHC	TXJ	ZMB	CNX	GMZ	JHP	LFB	NWZ	RWB	WLZ
NQB	RHX	TZC	ZNL	CPW	GPX	JHZ	LFC	NXD	RXH	WMB
NQC	RHZ	TZD	ZRP	CQL	GQD	JMG	LGB	NXG	RXL	WMC
NQD	RJC	TZL	ZRW	CQG	GSN	JMX	LGW	NXS	RXN	WNL
NQL	RKB	WBD	ZRX	CQK	GSX	JNL	LGZ	NZT	RZM	WPF
NRB	RLC	WBS	ZSD	CQS	GTK	JNQ	LHP	PBS	SBF	WPH
NRF	RMW	WCL	ZSL	CRJ	GTM	JNZ	LHZ	PFW	SCZ	WRB
NRL	RPB	WCN	ZWG	CSM	GTW	JPH	LNW	PFX	SDQ	WRF
NRX	RPJ	WFJ	ZWK	CZM	GWJ	JPM	LQB	PHF	SFC	WSM
NSX	RPW	WFN		CZS	GWP	JPW	LQG	PJD	SFL	WZF
NTP	RXJ	WGZ		DBP	GXD	JPX	LQH	PJM	SFQ	WZR
NWB	RXK	WHC		DBZ	GXR	JRF	LQZ	PJT	SHZ	XBG
NWD	RZF	WJD		DFH	GXS	JSD	LSG	PMG	SMB	XBT
NXZ	RZH	WJS		DFS	GZP	JSX	LSW	PMZ	SNJ	XDG
NZB	RZL	WKF		DHB	HBK	JTM	LTB	PNX	SWQ	XDK
NZJ	SBJ	WKH		DHF	HCS	JTP	LWB	PWB	SXB	XFL
NZP	SBK	WLC		DJP	HDJ	JTX	LWC	PWG	SXG	XFN
NZQ	SBW	WNB		DLN	HDP	JWD	LWJ	PWM	SXK	XFR
PBW	SDZ	WNJ		DPG	HFL	JWR	LXF	PXT	SXL	XGS
PCZ	SGP	WNQ		DPK	HFN	JXC	LXQ	PZG	SXQ	XHR
PGB	SHB	WPZ		DPX	HKC	JXM	LZG	PZM	SZL	XHL
PJB	SJM	WQK		DSF	HLB	JZB	LZS	PZR	TCX	XHS
PMF	SJX	WQS		DSQ	HLF	JZG	MCZ	PZS	TDK	XKC
PNB	SKQ	WSQ		DSZ	HLW	KBD	MFK	QBG	TGL	XKS
PWH	SMF	WTJ		DTJ	HLX	KBN	MGP	QBH	TGM	XKT

TABLE 3 (Continued)

38% con	42% 381								45% 349	
XLB	BDP	DNQ	GLJ	JWN	MHK	PXM	SGK	XGT	BDQ	DZX
XLF	BFK	DPF	GMQ	JZR	MJD	PXN	SHX	XHP	BDT	FCN
XMK	BGK	DPJ	GSB	KBZ	MKP	PZN	SJC	XKP	BDX	FCX
XNR	BGW	DPZ	GSC	KDP	MKW	QBD	SJL	XLS	BGX	FDT
XPF	BHD	DQZ	GSK	KDR	MXH	QBL	SJP	XNC	BJZ	FDW
XPZ	BHK	DSB	GTB	KFB	MXQ	QCL	SMZ	XNK	BKM	FHN
XRB	BHP	DSJ	GTX	KFD	NBG	QHM	SXC	XNS	BMQ	FKN
XRF	BJL	DSX	GTZ	KGD	NBX	QHZ	SXF	XPC	BMR	FKT
XSN	BJR	DTG	GZM	KGM	NCJ	QJT	SXJ	XPG	BNF	FMR
XTC	BMK	DTK	GZR	KGW	NCS	QKG	SZD	XPM	BNJ	FNJ
XTK	BPH	DTQ	GZX	KGZ	NDZ	QKN	TCG	XRC	BNL	FRH
XTP	BQK	DWM	HBD	KMB	NFH	QKT	TCP	XRG	BPG	FRP
ZBD	BQS	DWZ	HBQ	KMG	NFW	QKW	TCQ	XRN	BPT	FSD
ZBL	BSD	DXS	HCM	KMR	NGQ	QNG	TCW	XRZ	BTD	FZG
ZBN	BSG	DXZ	HCT	KNQ	NGW	QNJ	TDM	XSL	BTX	FZR
ZDM	BSZ	DZK	HDF	KNR	NHL	QNX	TDZ	XSM	BWG	FZT
ZDN	BTG	DZM	HDK	KNS	NJF	QSZ	TFD	XSQ	BXQ	GBW
ZDS	BTW	DZP	HFX	KRF	NJQ	QTF	TGN	XTM	BZL	GCR
ZFR	BXL	DZW	HKD	KSG	NJS	QTM	TGQ	ZDK	CJL	GDX
ZGD	BZM	FBD	HKT	KTG	NJT	QWC	TJN	ZFT	CMF	GDZ
ZGL	CFN	FBN	HMK	KWS	NJX	QWM	TKM	ZGT	CNJ	GJN
ZGM	CFR	FCS	HNL	KZR	NKP	RCP	TKP	ZKW	CNZ	GLQ
ZKR	CGL	FDM	HPB	LBH	NLD	RFB	TKQ	ZNP	CPN	GMW
ZLD	CGT	FHL	HQJ	LCW	NLH	RFJ	TLB	ZNX	CSG	GNL
ZLF	CJP	FJD	HQN	LDT	NPX	RGC	TLC	ZQT	CTF	GPC
ZLN	CKP	FJL	HQW	LFQ	NRH	RJD	TMC	ZRD	CTK	GPK
ZLP	CKX	FJN	HRC	LFX	NRP	RJG	TMJ	ZRL	CTW	GPL
ZNJ	CMW	FMB	HRJ	LGQ	NSK	RJH	TMZ	ZTP	CXT	GTJ
ZNR	CNF	FNW	HSJ	LGX	NSL	RJN	TPB	ZWL	DGB	GTL
ZPK	CNS	FNZ	HWD	LHQ	NSZ	RJT	TQX	ZWN	DGJ	GTP
ZPM	CSN	FPD	HWM	LHR	NTQ	RKP	TXH	ZWR	DGK	GTQ
ZPN	CWP	FPK	HXS	LHS	NWK	RKZ	TZN		DGW	GWM
ZRB	CWM	FPL	HZR	LJN	NXB	RMH	WBL		DHS	GWS
ZRH	CWR	FQB	HZS	LPJ	NXK	RMK	WBZ		DKB	GXL
ZSC	CZK	FRB	JBD	LPN	NZD	RNB	WCR		DKF	HDT
ZSH	DBH	FSC	JDB	LQF	NZS	RNF	WDH		DKG	HDW
ZSM	DBN	FSM	JDM	LQN	PBG	RNP	WDJ		DKP	HDZ
ZSN	DFB	FSX	JDP	LQX	PBH	RPX	WDZ		DKT	HKN
ZSX	DFK	FWK	JDS	LRC	PBN	RPZ	WGK		DKW	HMX
ZTN	DFN	FXC	JDX	LRF	PGX	RWP	WJN		DLW	HPF
ZWD	DGZ	FZL	JFT	LRX	PGZ	RXG	WKB		DMF	HPW
	DHM	FZN	JGN	LSX	PJS	RZK	WKP		DMW	HPX
	DJR	FZS	JLD	LWZ	PKH	RZP	WKQ		DNZ	HQK
	DKM	FZX	JLN	LZP	PLF	RZT	WMJ		DPB	HSD
	DKZ	GBN	JLW	LZW	PMC	SDF	WMQ		DPM	HSQ
	DLG	GDJ	JMQ	MBP	PNR	SDG	WNF		DQX	HSW
	DMH	GDM	JPG	MBS	PSJ	SDK	WPM		DTW	HTF
	DMJ	GJP	JSL	MCP	PWF	SDP	XBS		DWQ	HTK
	DMQ	GJR	JSN	MFS	PWK	SDW	XGM		DXM	HXM
	DNL	GJT	JTZ	MHD	PXK	SFZ	XGN		DXT	JDN

45% con

50% 30?

JDZ	MGZ	PHJ	RPK	TPX	BDN	DTF	HNC	LTQ	PDZ	SLZ
JFL	MHR	PHK	RJT	TQN	BDZ	DTL	HNS	LXC	PHT	SNQ
JHR	MJP	PJN	RTK	TWC	BFS	DWK	HPK	LXS	PLJ	SPB
JHT	MKC	PMH	RTP	TWM	BFT	DWP	HPZ	MCS	PLX	SQC
JMD	MKH	PMK	RTW	TXF	BGJ	DXR	HQC	MCT	PMX	SQF
JMZ	MKQ	PNJ	RWK	TXK	BHN	DZL	HQD	MDJ	PNF	SQN
JNH	MKZ	PNW	RWL	TXZ	BJN	DZR	HRF	MDQ	PNZ	SWC
JPB	MPW	PRJ	RWM	TZR	BJT	FCR	HTC	MGD	PSC	SWJ
JPL	MWD	PSB	RXM	WDF	BKP	FDS	HZD	MGX	PTW	SXD
JQT	MXS	PSK	RXP	WFS	BKQ	FDZ	HZM	MHP	PXR	SXM
JSZ	MZD	PTC	RZG	WKC	BKT	FHB	JBM	MHT	QHS	TBH
JTR	MZT	PTL	RZN	WKZ	BKX	FHR	JBR	MKB	QLS	TBJ
JWG	NBT	PTM	RZW	WLH	BKZ	FHS	JGR	MKS	QMC	TBM
JXP	NCG	PWC	SBN	WLN	BLP	FJR	JGS	MPJ	QNB	TBX
JZL	NDK	PXG	SCJ	WMF	BNR	FLJ	JHS	MPX	QNC	TDN
KCP	NFZ	PZL	SCQ	WMT	BPK	FPS	JMR	MQT	QNH	TDR
KCR	NGZ	QBS	SDJ	WNC	BQM	FQX	JPR	MSJ	QSC	TGX
KDM	NJB	QBT	SDX	WPB	BSP	FTJ	JPS	MTF	QSK	TKR
KDX	NKH	QDT	SFB	WPC	BTF	FTK	JPZ	MTW	QWK	TPJ
KGN	NLG	QMS	SFW	WPK	BTJ	FWS	JRG	MWG	QXT	TQG
KGT	NLW	QND	SGX	WQD	BWM	FXT	JRH	MWK	QZT	TXM
KPD	NLZ	QNZ	SJN	WRJ	BXN	FZD	JTN	MXF	RCL	WDL
KPH	NPR	QTG	SKB	WSL	CKW	GBD	JXT	MXK	RCM	WDT
KPM	NRG	QTJ	SLJ	WTF	CLJ	GBK	JZD	NBD	RDK	WFD
KPN	NRJ	QTK	SMJ	XDT	CLZ	GBX	KBR	NBJ	RDP	WGD
KPZ	NSD	QTW	SNX	XFD	CMG	GBZ	KCS	NCX	RFN	WGM
KRC	NTB	QWH	SQG	XFT	CMX	GDP	KDG	NCZ	RFP	WHD
KRP	NTC	QZN	SQJ	XNG	CNR	GLC	KHT	NDH	RHB	WHQ
KRW	NWF	QZS	SQK	XPK	CPH	GLX	KMD	NDL	RKD	WMD
KSH	NWG	RBK	SXP	XQT	CPK	GMB	KMS	NDX	RKG	WMK
KTR	NWJ	RBP	TBD	XRM	CQM	GNJ	KPF	NFD	RKN	WMZ
KWD	NWP	RCF	TCM	XSH	CSL	GPD	KPG	NGX	RKX	WNP
KWM	NXH	RCX	TCR	ZBS	CTG	GPM	KPR	NKT	RMX	WQM
LCN	NZC	RDJ	TDB	ZCL	CTL	GTC	KPX	NKX	RNJ	WQT
LGJ	NZF	RDW	TDG	ZCR	CTQ	GTN	KSC	NJD	RNW	WSB
LNJ	NZL	RFW	TDP	ZCT	CTX	GWT	KTC	NJL	RNZ	WSN
LNQ	PBD	RGB	TGC	ZDR	CWG	GXP	KTD	NJP	RPN	WTB
LPW	PBR	RGK	TGK	ZFD	CWK	GZT	LBD	NJR	RTB	WTD
LPX	PBT	RGM	THJ	ZGN	CWS	HBL	LCG	NPL	RWG	WTL
LRZ	PBX	RHL	TKB	ZGR	DBK	HBS	LCH	NRK	RZB	WTQ
LSB	PCF	RHP	TKW	ZHR	DBM	HBT	LDZ	NRW	SBD	WZJ
LSC	PCM	RKM	TLG	ZMS	DFL	HBW	LFH	NTW	SFD	XCH
LSQ	PDB	RLG	TLW	ZND	DFM	HCP	LFN	NZW	SFK	XCL
LTC	PFB	RLH	TLX	ZPH	DFP	HCR	LFR	PBK	SFN	XDR
LWF	PFC	RLN	TMH	ZRC	DGP	HDX	LFS	PCN	SLX	XJR
LWP	PFK	RMB	TMQ	ZSK	DMG	HFR	LJR	PCR	SGD	XMT
LWQ	PFM	RMZ	TMW	ZSP	DNF	HJR	LNR	PCX	SHQ	XND
LXG	PFN	RNC	TMX	ZWM	DNX	HLR	LQW	PDF	SJD	XNH
LZB	PGJ	RPF	TNJ	ZWT	DQB	HMB	LSD	PDH	SKC	XSC
LZF	PGT	RPH	TPC		DQM	HMZ	LTJ	PDR	SLH	XTB

TABLE 3 (*Continued*)

50% con	54% 270						58% 242			
ZCH	BDW	DTZ	JGM	MTP	RDX	WTG	BDM	FXD	LWD	PHR
ZHT	BHR	DZG	JLG	MTX	RDZ	XBR	BFD	FXR	LXD	PKB
ZLT	BHS	DZS	JLR	MWR	RHM	XCR	BFL	GCL	LXN	PKZ
ZNH	BLJ	FBK	JLS	MXC	RKF	XGR	BGM	GDB	LZT	PNH
ZRG	BPR	FBL	JMT	MXP	RNH	XHT	BHM	GDL	MDB	PNL
ZRM	BPS	FDN	JND	MZH	RNL	XLD	BHT	GMD	MDF	PSN
ZRN	BRJ	FKR	JRB	MZS	RNX	XPN	BKF	GQT	MDK	PRH
	BSW	FLQ	JRC	NBQ	RPG	XRK	BKH	GSL	MFT	PSD
	BTK	FMD	JRX	NBW	RWN	XSP	BLF	GZS	MGS	PSF
	BTM	FMT	JSM	NBZ	RXD	ZHN	BLZ	HDB	MGT	PSG
	BTZ	FNB	JTC	NDR	SCG	ZHS	BNH	HFD	MHQ	PSN
	BWS	FNR	JWS	NGL	SDM	ZJR	BPL	HLN	MJC	PTD
	BWT	FQT	JXS	NHD	SGL	ZMP	BQT	HPC	MKG	PTJ
	BXG	FRX	KBT	NHJ	SHC	ZMR	BQX	HPD	MKX	PTK
	BXS	FTL	KHN	NJC	SKX	ZMT	BSM	HPJ	MPC	PTX
	BZT	FTM	KNC	NJG	SLX	ZPD	BTN	HPT	MPG	PWD
	CJR	FTP	KPC	NLS	SMH	ZPR	BWK	HQM	MPH	PWS
	CKG	FTQ	KRM	NPG	SNH	ZPS	BWN	HRP	MQS	PXS
	CKR	FWR	KSD	NPH	SPF	ZPT	BXR	HRX	MRC	PZD
	CMK	FXL	KSM	NRC	SZN	ZRT	CGN	HSX	MSF	QLD
	CNH	FXN	KWP	NSB	TBF		CHG	HTM	MSG	QMD
	CNW	FXS	LBG	NSG	TBK		CHX	HTQ	MSZ	QTC
	CPL	GBL	LCQ	NSJ	TBW		CHZ	HTZ	MWT	QTL
	CQT	GBT	LCX	NSP	TDW		CLH	JGD	MXG	QTN
	CRF	GCP	LDW	NTD	TDX		CNK	JPT	MZR	QWL
	CRZ	GDK	LFW	NTZ	TGD		CNL	JRM	NBF	QWN
	CTP	GDT	LFZ	NXC	TJR		DGL	JRT	NCT	RCN
	CTZ	GMT	LNH	NXP	TKX		DKN	JRW	NFR	RDB
	CXN	GNZ	LPG	NZH	TMG		DLR	JSH	NGC	RDF
	DGQ	GPS	LPT	PBM	TMR		DMT	JTG	NGP	RDL
	DHN	GRJ	LPZ	PDJ	TNX		DNP	JWT	NGS	RFM
	DHP	GRX	LQS	PDM	TNZ		DNR	KCH	NHC	RFX
	DJT	GWL	LQT	PDX	TPM		DNW	KCN	NHK	RFZ
	DKR	GZD	LRW	PFR	TWQ		DSL	KCT	NJZ	RHD
	DKZ	HCN	LSN	PFS	TXL		DSM	KNH	NKG	RHN
	DLP	HDQ	LTG	PGC	TXQ		DWH	KNW	NPD	RLT
	DLS	HLZ	LTP	PJG	WBR		DXN	KNX	NQT	RLZ
	DMK	HPL	LXR	PKM	WHK		DZT	KRB	NRD	RMG
	DMZ	HQB	LXZ	PLR	WJR		FBS	KRD	NRT	RPC
	DNB	HQF	LZN	PMJ	WKT		FCL	KRN	NTJ	RTM
	DNJ	HMD	MFD	PSZ	WLP		FDJ	KRX	NTK	RTX
	DQG	HMQ	MGC	PTF	WNH		FLH	KTN	NTX	RWT
	DQN	HMR	MGK	PWL	WNZ		FMP	KWH	NWR	RZD
	DQT	HNZ	MJG	QCT	WPL		FNH	LBS	PCG	SBL
	DSG	HSL	MJS	QFT	WPN		FPT	LCR	PCL	SCL
	DSN	HTP	MPK	QHT	WQN		FRJ	LGC	PCS	SDL
	DTB	HTR	MRB	QKS	WRC		FRW	LNB	PCW	SGM
	DTM	HTW	MSW	QNK	WRH		FTC	LNC	PDN	SHL
	DTP	HTX	MTB	RBG	WRZ		FTR	LPH	PDS	SKG
	DTX	HWS	MTK	RDN	WSD		FWD	LQC	PHC	SLF

TABLE 3 (*Continued*)

58% con	63% 195				67% 140			71% 141		
SLN	BFR	GCT	MTQ	SKZ	BGS	KTZ	RKC	BDL	JMB	RTH
SLQ	BGD	GDN	NBK	SMQ	BKW	LBN	RLF	BGN	JNR	RWD
SNC	BGL	GDR	NCR	SMW	BLH	LCT	RPL	BRF	JRD	SCK
SQH	BGT	GMR	NDS	SPJ	BLX	LDS	RTG	BRL	JWL	SCM
SQX	BLG	GWR	NHB	SPM	BMS	LGN	RTL	BRX	KGR	SCN
SWB	BLQ	GZL	NHF	SPW	BNT	LGR	SCT	BRZ	KGS	SLC
TBP	BLR	HMT	NHQ	SPZ	BRH	LPR	SCP	BSN	KMP	SMX
TBQ	BLS	HPM	NHX	SQD	BZD	LSH	SCW	BTR	KNF	SPG
TCL	BMD	HPN	NKD	SQM	CFT	LTX	SHM	BZN	KNT	SQW
THC	BNQ	HPR	NLT	SWD	CHP	LWS	SLB	CGS	KPT	SWF
THZ	BNX	HRW	NPK	SWH	CHW	LZD	SMC	CHM	KSP	SWL
TKC	BNZ	HRZ	NTF	TBN	CLN	MCK	SMP	CMT	LDG	SWZ
TLR	BPD	HSM	NTG	TBZ	CRH	MDH	SNL	CPT	LDN	TBG
TMB	BRP	HSP	NWH	TCN	CSH	MDX	SPC	CRT	LGD	TBL
TPK	BSL	JBS	PDG	TFN	CSK	MKT	SPH	CRX	LPD	TBR
TPN	BSQ	JDR	PDT	TFR	CTN	MPR	SPX	CWN	LWR	TDL
TPW	BWD	JFR	PFD	THQ	DBR	MPZ	TFL	DGR	LZR	THF
TRF	BZR	JLP	PFT	TKG	DFR	MSB	TLP	DMB	MCR	THP
TWD	CGR	JMS	PGD	TMK	DGN	MSP	TND	DPH	MDR	TNR
TWK	CKS	JNP	PGK	TNC	DHR	MSX	TNG	DPL	MDW	TPD
TWP	CHK	JPD	PGL	TNH	DHT	MTG	TNP	DRJ	MRG	TPH
TXB	CHT	JTD	PGR	TNQ	DMR	MTZ	TPF	DRZ	MSD	TPL
TXR	CKT	KDN	PHM	TPG	DMS	MWS	TPZ	DSP	MTC	TRJ
WCT	CLG	KFR	PHW	TRC	DNS	MXD	TWL	DTN	MTD	TRL
WDG	CLT	KNB	PKN	TRG	DPW	MXR	TWR	FDR	MTJ	TRW
WFL	CLQ	KNP	PKX	TRZ	DRH	NFT	TXN	FNK	NCL	WCH
WKR	CLX	KRG	PMB	TXC	DWF	NPS	WDR	FNL	NDG	WFR
WMG	CMR	KRT	PMR	WCK	DWR	PBL	WHS	FRC	NHR	WGS
WMH	CMS	KTH	PSL	WGL	DWS	PDK	WKG	FRK	NHT	WHF
WMP	CNG	KWN	PTB	WGR	FLZ	PGM	WLS	FRL	NHW	WHL
WPG	CNT	KWT	PTN	WGT	FMS	PGN	WPD	FTB	NHZ	WHM
WPR	CPR	LDQ	PXD	WJZ	FTD	PGS	WRL	FTW	NSC	WHR
WTM	CTH	LFD	QMT	WKM	FTN	PHN	WSK	GLB	NTL	WHZ
WTN	CTM	LNZ	QNS	WMR	FTX	PHZ	WTR	GLZ	NTR	WKN
XNT	CZN	LPC	QTB	WNR	FTZ	PJR	XMP	GMS	NWT	WPT
XPS	DGM	LRT	QTH	WPS	GLT	PKF	XPD	GNR	NXT	WRT
XPT	DGX	LTF	RBD	WSC	GMC	PKT	XRT	GPR	PCH	XCT
XRD	DNH	LTN	RBL	WTZ	GND	PKW	ZNG	GRC	PDL	XLT
XTH	DPN	LTW	RCT	WZD	GNK	PLD	ZNS	GRZ	PDW	XPR
ZMD	DRX	LTZ	RDG	XMD	GPT	PLH	ZPL	GWK	PFL	ZNK
ZNT	DWG	LXT	RDH	XMR	GSD	PMT		HDS	PKC	ZRK
ZTR	DWT	MCX	RDT	XPL	HDR	PNC		HFT	PRB	
	FBR	MDP	RKT	XSK	HSC	PRW		HLS	PRL	
	FKD	MDT	RKW	ZHP	HTD	PTG		HQS	PRN	
	FLB	MHS	RLD	ZTH	JNS	PTZ		HRK	PSW	
	FLC	MKD	RLX		JPN	PWN		HRL	QSH	
	FNC	MPD	RTC		JRZ	QCK		HRM	QTZ	
	FSL	MRF	SCX		JSP	QTD		HWL	QWT	
	FSN	MRH	SHD		KDS	RGN		HWT	RFL	
	FWT	MRP	SKH		KPS	RGT		JGL	RFT	

TABLE 3 (*Continued*)

75% 109			79% 101			83% 84		88% 48	92% 43	96% 13	100% 10
BKG	LTH	WFT	BDG	MPS	ZBR	BGR	PHB	BLT	BKD	BLD	DNT
BKN	LTR	WGN	BDR	MRT		BKR	PHL	BRG	BNK	BND	DPT
BKS	LWT	WKD	BDS	MRX		BLW	PHS	BRT	BRN	BRD	DRK
BMP	MDG	WKS	BLN	MTR		BMT	PLN	BTL	CHL	DSH	HRD
BRM	MDZ	WLF	BNG	MXT		BRK	PLW	BXT	DBT	DWN	PNK
BSK	MPT	WMS	BNS	NBR		BSH	PRC	CHF	DRT	FLP	SLW
BXD	MRD	WRG	BRW	NBS		BTH	PRF	CRN	DSK	FRM	SNK
CHN	MRZ	WRM	BWL	NGD		CHR	PRK	CRW	FLT	FSK	SNW
CLR	NBL	WTC	BWR	NGT		CLF	PRM	DMP	FND	GLD	SWM
CMP	NCK		CHS	NHP		CLP	PSH	DRG	FRD	GRN	WHP
CPS	NGR		CRL	NHS		CLS	QLT	DRP	GRD	HLD	
CRG	NKS		CRP	NTH		CLW	RHT	FDL	GRL	LFT	
CSP	NPT		CWT	PHX		CRK	RMP	FLD	GRT	TWN	
CTR	NWS		CZR	PKR		CRM	RPD	FLW	HLT		
CWL	PKD		DBL	PKS		DFT	RPT	FNT	HRT		
DRB	PLG		DBS	PLB		DGT	SCH	FSH	JMP		
DRF	PLZ		DGS	PLC		DPR	SHK	GLW	KNG		
DRL	PMD		DKS	PMS		DRM	SKF	GRB	LNG		
DTR	PNG		DLT	PRG		DRW	SKM	GRP	LRD		
FLN	PRX		DNG	PRT		DZN	SNZ	HRN	LTD		
FLS	PSM		DNK	PRZ		FCT	SPD	HZL	MBR		
FNS	PTH		DPS	PTR		FLR	SWP	JCT	MSH		
FRN	PWT		DRN	PWR		FLX	SXN	KND	MSK		
FRT	QNT		DTH	RBT		FTH	TGR	LNT	PKG		
GDS	RBN		FHT	RFC		FWN	THK	LWN	PND		
GLN	RCH		FRZ	RND		GLR	TLD	MCH	RFD		
GLP	RDM		FWL	RPM		GNT	TMD	NSH	RNG		
GNS	RGD		GBR	SGN		HMP	TXG	PHD	RNK		
GNW	RGL		GBS	SLG		HMS	WDN	PLS	SHN		
GRM	RMD		GLS	SMG		HND	WLD	PLT	SHP		
GWD	RMT		GMP	SMK		HNT	WNS	PNT	SKN		
HBR	RTD		GRK	SND		HTL	WRD	PRD	SKP		
HCK	RTN		GRW	SNF		JLT	WRK	RCK	SLP		
HDN	SDN		GSP	SPK		JNT	WSH	RNT	TCK		
HKS	SHF		GTR	SPL		JRN		RTZ	THN		
HLP	SHW		GWN	SQB		LBR		SKD	THR		
HNR	SKW		HCL	SWK		LGT		SLD	TNK		
HPS	SMD		HDL	THW		MDS		SNG	TRK		
HSB	SNB		HNK	TRB		MFR		SNP	TRP		
HTN	SQL		HQT	TRD		MGR		SPN	WND		
JDG	TCH		HRB	TRM		MJR		SWG	WNG		
JHN	THB		HSK	TXD		MRJ		SWN	WNK		
JNC	THM		HWK	WDS		MRK		THD	WRP		
JNX	THX		JNG	WHN		MRW		TMP			
KFT	TKN		LGS	WHT		MSC		TRN			
LDR	TPR		LNX	WLT		MSQ		WNT			
LHT	TRH		LPS	WSP		MTH		WRN			
LND	TRX		LQD	WTH		NSW		ZNC			
LNS	TWG		LRN	XMS		PCK					
LRG	TXP		LSP	XTR		PCT					

dropped to 29 per cent These are the most desirable for test purposes.

d. In constructing lists of consonant syllables it is possible to have a sequence of six syllables without any repetition of letters

e All elements of the unit are comparable whereas, in nonsense syllables, the vowels and consonants are qualitatively different.

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LA VALEUR ASSOCIATIVE DES SYLLABES DE CONSONNES À TROIS PLACES

(Résumé)

On a demandé à vingt-quatre sujets de donner la signification, s'il y en avait, de 4534 syllabes de consonnes à trois places, qu'on a présentées individuellement sur un tambour de mémoire, chacune pendant quatre secondes. On a déterminé la valeur associative de chaque syllabe sur la base du pourcentage des réponses. Celles possédant de la signification selon l'opinion de tous les sujets devaient avoir une valeur associative de 100% et celles auxquelles nul sujet n'a répondu ont été groupées à 0% avec toutes les possibilités intermediares mises en échelle entre ces limites

Une comparaison des syllabes de consonnes et des syllabes non-sens selon la classification de Glaze montre que les deux types de matériel ont des distributions très différentes Ses syllabes sont presque uniformément divisées en seize groupes de signification, tandis que les syllabes de consonnes sont plus égales à la courbe normale

Les avantages de ce matériel comme supplément des syllabes ordinaires non-sens sont (*a*) 4534 unites sont disponibles, (*b*) Le materiel est moins significatif que les syllabes non-sens, ayant une valeur associative moyenne de 43% au lieu de 50%; (*c*) Il y a 3138 syllabes de consonnes avec une valeur associative de non plus de 50% et la valeur associative moyenne de ce groupe seul n'est que de 29%, (d) Dans les listes de test il est possible d'avoir une série de six syllabes sans aucune répétition des lettres; (e) Tous les éléments de l'unité sont comparables tandis que, dans les syllabes non-sens, les voyelles et les consonnes sont qualitativement différentes.

WITMER

DER ASSOZIATIONSWERT DER DREISTELLIGEN KONSONANTENSILBEN

(Referat)

Vierundzwanzig Vpn. wurden nach der Bedeutung, wenn irgend eine Bedeutung vorhanden war, von 4534 dreistelligen Konsonantensilben gefragt, die einzeln auf einer Gedachtnistrommel fur je vier Sekunden dargeboten wurden Der Assoziationswert jeder Silbe wurde auf Grund des Prozentsatzes der Antworten bestimmt Diejenigen, die bedeutungsvoll von allen Vpn. beurteilt wurden, bekamen einen 100% Assoziationswert, und diejenigen, auf die keine Vp antwortete, wurden als 0% bezeichnet, wahrend sich alle dazwischenliegenden Moglichkeiten zwischen diesen Grenzen gruppierten.

Ein Vergleich der Konsonantensilben mit sinnlosen Silben, wie sie von Glaze klassifiziert sind, zeigt, dass die zwei Arten von Materialien zwei sehr verschiedene Verteilungen besitzen Seine Silben sind beinahe gleichmassig in sechzehn Gruppen der Bedeutung nach eingeteilt, wahrend die Konsonantensilben sich mehr der Normalkurve annahren

Die Vorteile dieses Materials als Erganzung der gewohnlichen Sinnlosen Silben sind: (*a*) 4534 Einheiten sind zur Verfugung, (*b*) das Material ist weniger bedeutungsvoll als sinnlose Silben, indem es einen durchschnittlichen Assoziationswert von 43% anstatt 50% hat, (*c*) es gibt 3138 Konsonantensilben mit einem Assoziationswert von nicht mehr als 50% und der Durchschnittswert von dieser Gruppe allein ist nur 29%, (*d*) in Testreihen ist es moglich, eine Reihenfolge von sechs Silben ohne irgend eine Wiederholung der Buchstaben zu haben; (*e*) alle Elemente der Einheit sind vergleichbar, wahrend bei sinnlosen Silben die Vokale und Konsonanten qualitativ verschieden sind

WITMER

A STUDY OF THE RELIABILITY AND VALIDITY OF THE BÜHLER INFANT SCALE*[1]

From the Strong Memorial Hospital, Rochester, New York

RUTH M. HUBBARD

This study is an attempt to add to our understanding and interpretation of scales for testing infants by studying the consistency and predictive capacity of one such scale, the Buhler Infant Scale described by Charlotte Buhler in her book, *The First Year of Life* (3).

SUBJECTS

The infants to be tested were obtained through the Well Baby Clinic of Strong Memorial Hospital, Rochester, N. Y. The examiner spoke to individual mothers in the clinic, describing the tests, telling them an effort was being made to learn what normal babies could do at various ages and asking if they would be interested in bringing their babies for a test and for retests There was selection from this group of infants only in the fact that the mother must be able to speak English enough to understand the examiner and must be willing to bring her baby, and that the child's month birthdate must fall close to the days for which appointments were being made Even though mothers were at first interested in the tests, they frequently were unable to keep appointments because of inclement weather, illness of the baby or of someone in the family, inability to make arrangements for transportation, or because they had lost interest in the tests. Actually only about half the appointments made were kept.

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[1]Acknowledgment is here made for the kind assistance and cooperation of the following people in making possible this study Dr N W Faxon, Superintendent of Strong Memorial Hospital, Dr S. W. Clausen, head of the Department of Pediatrics, and Dr. E K. Clarke, head of the Department of Psychiatry in the University of Rochester School of Medicine and Dentistry, Dr Isabel Wallace of the College for Women, University of Rochester, and the following students at the College for Women who assisted with record taking Frieda Mikell, Marian Redfern, Betty Rosenberg, Jean Horton, Challice Ingelow, and Clarice Keenan

Dr Hazel M Cushing has contributed very stimulating comment.

At the request of certain social agencies, the Rochester Community Home for Girls and the Children's Service Bureau, 25 of their infant charges were tested

There were in all 78 babies, 39 boys and 39 girls. All children included in the study were in good physical condition. The age distributions for first, second, and third tests, and for those children who were later given the Merrill Palmer scale, are shown in Table 1 These ages were computed from birth; no attempt was made to compute them from conception

TABLE 1
AGE DISTRIBUTION

Age in months	First test	Second test	Third test	Merrill Palmer	Totals
37-38				1	1
35-36					
33-34					
31-32				1	1
29-30				3	3
27-28				3	3
25-26				2	2
23-24				2	2
21-22				3	3
19-20	1	1		5	7
17-18	3	2		4	9
15-16	3	7	1	1	12
13-14	5	6			11
11-12	12	6	5		23
9-10	9	3	2		14
7- 8	12	9			21
5- 6	13	6			19
3- 4	13				13
1- 2	7				7
Totals	78	38	8	25	149

The Testing Situation

The testing was carried on in a roomy, out-patient office, undisturbed, containing only the equipment necessary for giving the tests and chairs for seating parents. A regular hospital crib, small size, was placed head end toward the window. At its head and along the right side stood a cloth-covered screen and behind the screen a large table on which the testing materials were placed When an observer recorded responses she stood at a high table to the left of the crib about eight feet away. Parents were seated from

four to six feet from the foot of the crib and a little to the right, upon occasion, when the child seemed to be playing for parental attention, parents moved behind the screen.

In a very few cases babies were thought to be a little fearful of the room at first, because they had recently been hurt in the clinic, but most of them were sufficiently accustomed to the hospital surroundings through their visits to the clinic, so that they showed no fear. The time of day for appointments was arranged so as to interrupt the child's feeding and sleeping schedule as little as possible. However, some mothers were very irregular in their schedules and brought babies tired or hungry to the tests. When this happened the test was usually discontinued, in two cases the baby was partially fed during the testing period In all cases the individual (mother or social worker) who brought the baby was present in the testing room. This gave such children as were fearful a greater feeling of security and often made it possible to bring out motor responses which the examiner alone could not elicit Never were more than two visitors allowed and only one was asked to help in any way In a few instances, mothers in their over-anxiety to have the child do well interfered with the tests, and had to be asked to remain quiet or stay out of sight.

The testing instructions as given by Buhler (3) were obeyed as closely as possible in administering the tests. Where directions were equivocal, they were interpreted consistently throughout the experiment; these items will be discussed later. The test materials were ordered through Dr. Buhler from Vienna. Non-washable materials were coated with shellac. All materials were thoroughly washed in warm soap suds after each test to prevent any danger of infection Some materials wore out and had to be replaced from local stores. Rattles were easily replaced; it was found preferable to use rattles with single straight handles, rather than those with double handles. The chicken in a ball was replaced by a dog whose eyes and tongue protruded when he was squeezed; the reaction of babies to the dog seemed to be very similar to their reaction to the chicken in a ball.

For about the first half of the experiment an undergraduate student in psychology was used as recorder. Because it was difficult to arrange convenient schedules for all persons concerned and because it was felt that, in clinical practice, two persons could not be expected to give their time to a single test, the examiner later

did her own recording. This slowed the giving of the test somewhat but did not noticeably lessen the amount of recording done, because abbreviations were used and the notes amplified immediately after the test was finished.

Babies were tested as closely as possible to their month birthdays. Ninety-eight tests were made within four days of the month birthday, 109 were made within a week of the month birthday, while 15 were made at intervals longer than a week before or after the birthday

Reliability

The internal consistency of the scale is our first concern Buhler reports no data on this point for this scale. Other infant scales have shown high internal consistency, for single month levels. Linfert and Hierholzer (9) report a mean corrected alternate-item reliability coefficient of .81 for their scale, using single month levels Bayley (1) reports for the California First Year Mental Scale an average split-half reliability coefficient of .82 for single month levels.

TABLE 2
Alternate-Item Reliability Coefficients

	Number	Reliability coefficient for half scale	Corrected for no of items in total scale	Corrected for wide range
First tests only	78	97	986	73
Second tests only	38	.97	987	.86
Third tests only	8	.98	990	.95
All tests combined	124	98	.990	80
Tests, developmental ages 1 through 11 months	75	.96	.978	.84
Tests, developmental ages 12 through 22 months	50	84	91	54

In Table 2 are presented alternate-item coefficients for the Buhler scale, obtained by correlating mental ages derived from odd items only with mental ages derived from even items only. Since there were so few cases at any one month level, all ages are combined. The second column in the table shows the raw coefficients, the third column gives these coefficients corrected according to Edgerton and Toops' method (5) for the length of the total scale. Because the

range of ability represented by these coefficients is 11 to 22 months of developmental age, these are not comparable with coefficients obtained for single month levels. We find from our data that the range of ability included in 11 months is three times the range included in one month level, and the range of ability included in 22 months is about six times the range included in one month level, etc. Correcting each coefficient of the third column for the extent of its range we obtain the coefficients in the fourth column (8, p 221). These represent the probable reliability for single month levels and are more nearly comparable with the coefficients quoted by Linfert and Hierholzer and by Bayley. The internal consistency of the Buhler scale for the first year seems to be about the same as that of the other two infant scales However the Buhler scale for the second year of life is considerably less consistent.

A more important criterion of the value of the scale is the agreement between scores on first and later tests Buhler (3, p 275) reports that she retested 25 children at intervals of four to 12 months and that "the result of the first examination agreed with the result of the second with the exception of two cases" She does not report test ratings for all 25, but reports them for five children who are considered to be unexceptional cases The second developmental quotients in these five cases differ from the first quotients by 0 to 20 points. She states that "there is no case in which the result of retesting directly contradicts our prognosis"

For the present experiment it was planned that mothers would bring their babies back regularly at two-month intervals for retests Few mothers were sufficiently interested to do this regularly. Because of broken appointments, the intervals between first and second tests vary from one month (a case that accidentally returned too soon) to nine months, with an average at four months The intervals between first and third tests vary from five to nine months with an average at six and a half months Since there were so few cases no separate computations of reliability were made for the different length intervals

In Table 3 are presented the changes in developmental quotient from test to retest The changes are predominantly positive when the second test is compared with the first This would suggest the babies were much more accustomed to the test situation at the time of the second test, if we did not find more negative changes from

TABLE 3
CHANGE IN DEVELOPMENTAL QUOTIENTS AT RETEST

Points of change in DQ	First to second test	Second to third test	First to third test
46 to 50	1		
41 to 45	1		
36 to 40	1		
31 to 35	3		
26 to 30	2		1
21 to 25	5		0
16 to 20	4		0
11 to 15	7	1	1
6 to 10	6	0	2
1 to 5	8	2	1
0	0	0	0
−1 to −5	1	2	2
−6 to −10	3	2	0
−11 to −15	1	1	0
−16 to −20	1		1

second to third tests, when the babies should be still better accustomed to the tests The median amount of change from first to second test is +12 4 points of developmental quotient; the median amount of change from second to third test is —2 5 points of developmental quotient Changes as great as —19 and +46 points occurred in individual ratings Bayley (1) found less agreement between test and retest when the interval was longer Although we have too few cases to make any such comparison valid, still the few cases that we have show no consistent relationship between length of interval and variability in score.

Retest reliability coefficients are shown in Table 4. Apparently

TABLE 4
RETEST RELIABILITY COEFFICIENTS

	N	Coefficient	Probable error
1st test vs 2nd test, both sexes	44	70	±.05
2nd test vs. 3rd test, both sexes	8	.94	±.03
1st test vs 3rd test, both sexes	8	75	± 10
1st, 2nd & 1st tests vs 2nd, 3rd & 3rd tests, boys	28	69	±.07
1st, 2nd & 1st tests vs 2nd, 3rd & 3rd tests, girls	32	70	± 06
1st, 2nd & 1st tests vs 2nd, 3rd & 3rd tests, both sexes	60	.70	± 04

(so far as can be estimated from the small number of cases) second- and third-test ratings are more stable indications of a child's ability than first-test ratings The last coefficient in the table was obtained by combining all tests given, in order to use as many comparisons as possible In the course of the experiment a similar coefficient was calculated using only half as many cases This preliminary reliability was .67 and so suggests that the .70 reported here is a fair representation of the constancy of the test ratings.

Bayley (1) reports an average correlation between ratings on consecutive tests one month apart of .82, between ratings on alternate tests two months apart of .70 Even though the average interval between our first and second tests with the Buhler scale was four months, still the agreement between ratings is fairly close, represented by a correlation of .70. Our cases are too few to lead to conclusive results, but the indication seems to be that the Buhler scale gives fairly reliable ratings; that for prediction for individual children, at least two tests should be made

VALIDITY

Another important criterion for the scale is the agreement of its ratings with other measures of intelligence. Muhlenbein and Furfey (11) report correlations between infants' ratings on the Linfert-Hierholzer scale and Stanford Binet ratings made four years later, ranging from —.34 to —.11 for three single age groups of 26 to 28 children each. The total group of 81 infants' tests correlates .00 with Binet ratings made four years later. Bayley (1) reports a correlation of .22 between the average score of a child in the 7th, 8th, and 9th months with his performance in his third year

To obtain a measure of the validity of the Buhler scale as many children as possible were tested with the Merrill Palmer performance scale when they became old enough Their average age at the time of the Merrill Palmer test was 23.4 months with a range from 16 to 37 months The correlations between Buhler and Merrill Palmer ratings are shown in Table 5 The last column of the table shows the raw correlations corrected for attenuation (8, p. 204). For the attenuation formula the reliabilities used were, for the Buhler test, $r=.70$ from Table 4 and for the Merrill Palmer test $r=.72$ as reported by Stutsman (13) for S.D. scores on children two to five years old, retested after an interval of two months. It will be seen

TABLE 5
VALIDITY COEFFICIENTS

	N	Average interval between tests	Range of interval length	Correlation coefficients	Correlation coefficients corrected for attenuation
1st Buhler test vs. Merrill Palmer	25	13 2 mos	1 to 26 mos.	.37± 11	52
2nd Buhler test vs. Merrill Palmer	15	10 1 mos	2 to 24 mos	.70± 01	99

that these children were not only younger at the time of their Merrill Palmer test than the children in the two studies of infant scales reported above, but also that the interval between tests was shorter Also these two scales are rather similar in type, largely dependent upon manipulative capacities. Perhaps these three factors account for the closer relationship found here between infant test ratings and preschool test ratings. There seems to be some tendency for those children who rate high on the Buhler scale to rate high also on the Merrill Palmer, and the agreement between the two scales is much more marked if the second of two infant test ratings is considered

Another indication of the validity of the scale is the distribution of scores. Table 6 presents the distribution of developmental quotients for children whose chronological ages were under one year and for those one year or over. Considering that the group is small the distributions are fairly regular, except for the skewing toward

TABLE 6
DISTRIBUTION OF DEVELOPMENTAL QUOTIENTS ON INITIAL TESTS

DQ	Number under 1 year	Number 1 year or over
160		1
150	5	1
140	1	1
130	2	0
120	9	3
110	11	3
100	18	4
90	5	4
80	6	1
70		
60		
50	1	

high scores and the presence of some which seem to be freak scores

The average mental level of the group is another way of gauging the validity of the scale. It is to be noted that these infants came from underprivileged homes, homes being assisted by relief agencies and being given free medical care. Studies (15, 2, 7) of school children from such underprivileged homes as these have shown IQ's about 10 points below the average for the general population. Exact data on infants from such homes are not available Ripin (12) finds that infants in orphanages are not different in general mental level from infants in their own homes up to the age of six months but that above that age there is a "marked difference" in favor of the private home group even though the homes were of low socio-economic status. The infants used in standardizing the Buhler scale were in a receiving home awaiting adoption or placement in homes. Buhler makes no statement as to whether this fact was considered in evaluating test responses. One might expect, therefore, that average children would rate above average on this scale.

Table 7 presents the average developmental quotients made on

TABLE 7

AVERAGE DEVELOPMENTAL QUOTIENTS ON FIRST TEST FOR CERTAIN GROUPS TESTED

Group	Number	Developmental Quotient	Standard Deviation
Infants from Well Baby Clinic, all ages	47	115 5	22.5
Infants from social agencies, all ages	25	107.2	13 3
Well Baby Clinic, 2-6 months	22	110 1	22 7
Well Baby Clinic, 7-12 months	19	123 7	22 1
Well Baby Clinic, above 12 months	6	109 7	11 2
Social agencies, 2-6 months	8	105 3	11 2
Social agencies, 7-12 months	11	109 0	13.5
Social agencies, above 12 months	6	106 5	13 4

first tests for groups of infants used in this study These babies run significantly above average in mental ability as it is measured by this scale Children from seven to twelve months old, who should, according to Ripin's results, be beginning to show the effect of their meager environment, rate even higher than children two to six months old. Even though the number of cases here is not large, this result suggests a doubt of the adequacy of the standardization of the scale.

In the years represented by this testing program, many persons were having to seek help of social agencies and free medical care who in more prosperous years would have been independent. May not this fact cause children brought to dispensaries, etc, to be brighter than similarly selected children a few years ago when the studies cited above on underprivileged families were made? To test this hypothesis some few items of social history were collected from as many parents as possible. The data are incomplete because some children were illegitimate and nothing was known of the fathers Also data as to mother's education were not always available. The average Barr rating (14, p. 67) for the occupations of 41 employed fathers was 8 18, slightly above the average of the general population and about equivalent to the occupational level of plasterer or general painter This may not be a true indication of the father's abilities because, on the one hand, many reported they had held occupations of higher level a few years ago and on the other hand many were at the time unemployed. The average education of 37 fathers was 8.5 grades; of 51 mothers, 10 grades. The education of those parents for whom data were not available may be lower than the education of these reported Considering, however, both occupation and education of the parents as an indication of their mental level, the group seems to be just about average in ability and therefore a little above the usual out-patient clinic level.

Even though their parents may be average in intelligence still this group of children seems to rate unusually high. Thirty-nine per cent of children under one year rated superior or higher on their first tests; 33 per cent of those one year or over rated superior or higher.

Before we judge the Buhler scale too harshly, it is to be noted that on the Merrill Palmer scale also these children rated surprisingly high The average Merrill Palmer rating of 25 children so tested was High Average, and 15 per cent of the 25 rated Superior or Very Superior. Even considering the fact that the more intelligent children were probably returned by their parents for retests, this suggests that our group is probably of higher mental level than their economic and educational level would lead one to expect.

Under the circumstances of the present study it was not possible to select infants in representative proportions from all occupational levels. Since the scale seems to be fairly reliable in comparison with other infant scales and to have some predictive capacity with respect

to ratings on preschool tests, it would seem worth while that it be given to a large group of representatively chosen infants to determine whether or not its ratings are actually spuriously high for the general population.

Administration of the Scale

In many places the instructions for giving this scale are equivocal or incomplete. The procedures decided upon for use in this study are described here, not because they represent anything final by way of standardization but because they are one further step in the use of the test. They are presented in the hope that later users of the scale will be enabled better to standardize their procedure before beginning, and to be able to obtain more reliable and valid results.

In this study all chronological and developmental ages were computed in terms of months and days, making the quotients as accurate as possible.

Buhler recommends the giving of five test levels to each child, the level at his own month age, two month levels below, and two above (3, p. 195). Many of the children, the detailed report of whose tests she gives, did not pass all tests at the lowest of these five levels, nor fail all tests at the highest of the five levels given. In our practice, we tested each child on a level low enough that he

TABLE 8

Scatter of Test Successes

Age in months	Number of children	Average scatter, month levels	Range in test levels
2	6	3.8	3 to 5
3	6	5.1	4 to 6
4	7	4.7	4 to 6
5	8	5.5	4 to 8
6	11	5.8	4 to 8
7	10	6.5	5 to 9
8	11	6.6	5 to 8
9	7	6.9	5 to 8
10	8	6.5	4 to 8
11	10	6.7	5 to 9
12	12	6.1	4 to 9
13	5	6.0	4 to 7
14	5	5.0	4 to 6
15	6	5.1	3 to 8
16	5	4.2	3 to 5
18	5	3.8	3 to 4
19	2	6.5	6 to 7

passed all tests and continued testing to a level high enough that he failed at least all but one test This was done because we wished to make *no a priori assumptions as to the normal scatter of an infant's* successes but rather wished to discover the extent of such scatter as measured by this scale. Table 8 shows the amount of scatter found. If the testing for each child had been limited to five test levels, 56 per cent of the children would have been incompletely tested, since this percentage of the group scattered over more than five test levels. If the testing for each child had been limited to six test levels, 32 per cent of the children would still have been incompletely tested *It would appear that the more desirable practice would be testing* from the level at which the child passes all tests, through the level at which he fails all.

There is a very serious defect in the joining of the first-year scale to that of the second year. The first-year scale includes one series of ten tests for each month level from two to eleven months inclusive, each test carrying three days' credit The second-year scale includes ten tests for each three-month period, 12 months to 14 *months 30 days, 15 months to 17 months 30 days, etc., each test* carrying nine days' credit If a child passed all tests at eleven months he would be given a developmental age of eleven months. If he passed all the tests on the next higher (three-month) level he should *logically be given a developmental age of fourteen months.* Buhler recommends, however, (3, p. 198) that the basal score for children between 12 and 15 months be 12 months and that credit for all tests passed be added to this. This would add one month to the child's *developmental age without any tests having been given for it,* then a child 12 months old would receive full credit for one extra month of developmental age whereas at 11½ months he would receive no part of that credit. Also a child who passed some but not all of the tests in the 12- to 15-month level would receive no part of that extra month's credit The developmental quotients of individual children tested twice, once before 11 months and once after 12 months, would not be comparable because of the month added gratuitously For *these reasons we felt we could not adopt Buhler's method of credit*ing We considered using the already obtained developmental age of 11 months as the basal score for the 12- to 15-month tests, and adding credit for any tests passed above this level This procedure, however, made ratings obtained on the second-year scale incomparable

with those obtained on the first-year scale by being too low. It was necessary to find a way to add the month that should make the extra credit obtained proportional to the brightness of the child. To do this we re-evaluated the tests of the 12- to 15-month level so that success on all tests would carry four months' credit instead of three months, and each individual test would carry 12 days' credit instead of nine days'. This overweighted the tests of this level in proportion to other tests of the scale, making them have more effect on the final score. However, the advantage derived from giving credit proportional to the number of tests the child passed seemed to outweigh this disadvantage.

In our administration of the tests, the child was presented with only one toy at a time unless the test specifically required more. This was done in order to avoid overstimulation and to obtain attention as undivided as possible to the test being given. Specific methods of giving certain tests are described in the following paragraphs, Roman numerals indicate the month level, and Arabic numerals the number of the test in that level.

Test II 8 Reaction to Changing Tone of Voice. This test and VI 9 Imitating Sounds are difficult to standardize from person to person without actual practice. The contrast between normal and changed voices cannot be described in exact terms. Also the examiner almost inevitably alters the contrast to suit the child, making it mild for the child she expects to be frightened and making it marked for the children she considers phlegmatic.

III 6 Changed Reaction upon Repeating the Presentation of an Auditory Stimulus. In this test we used the whistle only, not the voice.

III 8 Mask Test. Like McGraw (10) we found fright to be a less frequent response to this test. One of six two-months babies was frightened, two of six three-months babies and three of seven four-months babies. There was staring and widening of the eyes, followed by smiling or even an immediate broad smile.

IV 1 Expression of Displeasure When Adult Stops Playing with the Child. For this test unstandardized speaking, singing, and playing are recommended before the examiner withdraws from the child. In our testing, the examiner merely withdrew after certain other tests involving play with the child had been administered. If, after III 1 Returning the Glance with Smiling or Cooing, the child looked

after E, III 7 Reaction to the Disappearance of the Human Face, was credited. If, after the child had been doing the grasping tests, IV 3 and 4 and the diaper experiment IV 5, the child showed more active displeasure when E withdrew, test IV 1 was credited

IV 4 Grasping a Touched Object. The instructions here do not tell how much help to give. We lightly touched the back of the child's hand with the rattle. If this did not elicit the correct response the rattle was placed in contact with the child's palm. If he grasped firmly, credit was given.

IV 7 Positive Reaction to Light The tests to be given in the dark were given by merely putting a black cloth over the crib, because the noise of darkening the room was too disturbing The black cloth was pulled over the crib slowly while talking and smiling at the child, so as to minimize his fear. Both this test and VII 6, Loss of Interest in a Repeated Stimulus, were omitted with some children who showed marked fear by crying

The imitative tests *III* 9 Imitating Facial Movements, (pursing lips), *IV* 9 Wrinkling the Brow, *V* 9 Sticking out the Tongue, and *VI* 9 Imitating Guttural Sounds, are said in the instructions to be demonstrated for three to ten minutes if the child does not respond correctly. Comparing these items with other scales and noting the behavior of infants in this study, such a period seems to be too long At 20 and 28 weeks, Castner (4) reports 20 seconds as long enough to elicit the prehension response if it is going to appear in the child. The Buhler imitative tests are given to infants of three, four, five, and six months In practice we found if the response did not appear in one minute it did not appear at all. However, to make sure, each of these tests was repeated twice later during the testing period. Judgment as to whether the imitative response appears is highly subjective.

V 1 Reflecting Friendly and Angry Facial Expressions, *VI* 2 Distinguishing between Friendly and Angry Talking, and *VII* 1 Distinguishing between Angry and Friendly Facial Expressions are three more unstandardized tests. The remarks made are to be extempore and one finds it very hard to scold a baby convincingly Responses to these were hard to elicit, possibly because the scolding was unconvincing but also because mock-anger is frequently a part of family play with a baby Very often the scolding tone elicited first a questioning serious expression and then a broad smile Such responses

seemed to be a correct adjustment to the situation as a whole and were therefore credited.

VI 3 Sitting with Support, was credited if the child sat for even so short a time as half a minute. The instructions are indefinite; probably a longer sitting should have been expected.

VI 6 Displeasure at Unsuccessful Grasping. The response of several energetic children was not a negative expression, crying, resentment, or objection, but a more forceful reaching with a "determined" expression This response was credited because it seemed a more mature response than the negative one

VII 2 Locomotion was difficult to elicit. Mothers' spontaneous reports of children's locomotive responses were credited, if according to detailed descriptions this credit seemed justified

VII 5 Pushing Away a Stimulus. This test was difficult to score because some children quite capable of forceful, directed pushing in other tests, suffered the annoyance of this test without objection The same stimulation had happened to them so often in the home at bath time that they were in the habit of submitting.

VII 8 Taking a Toy Away from an Adult was not credited unless the child actually got the toy, but the toy was held loosely in E's clasped hand.

IX 3 Understanding Gestures. Gestures have apparently become a game for many children. More of them laughed at the threatening finger or tried to take it than were fearful. For this reason, the test was scored mainly on the basis of the response given to the welcoming gesture.

IX 4 Playing Cuckoo. For this test the words used were "Where's the baby?" and "There she is" instead of "Cuckoo" and "Da da." This is in line with the current tendency to avoid baby talk to infants

IX 5 Kneeling with Support. It is difficult to learn from the directions how much support should be given the child; we were not sure whether the child should be expected to hold the position without any support or whether he held it with a continuance of the help E gave in getting him in position. Therefore E gave light support with both hands and if he stiffened and held the position erectly with this support the test was credited The number of credits given for the test shows that giving the test in this way made it too easy. Of the children given the test at six months, three passed and

two failed, at seven months five passed and three failed, at eight months eight passed and three failed, at nine months seven passed and none failed, at ten months eight passed and none failed, at 11 months eight passed and two failed Above this level all passed.

IX 9 Pocket Test is also uncertainly described, as to size of toy used, depth of pocket, particular toy chosen, repetitions of test. In our work, the small metal snapper was used, this was shown to and sounded for the child, then dropped into a pocket six inches square, if he did not reach for it the test was repeated as many as four times, at the end even holding the pocket in such a way that the child could see the snapper in it Children differed markedly in their spontaneity in reaching and the item seemed less an intellectual than an emotional test

X 2 Organized Play with an Adult requires sufficient confidence in the examiner on the part of the child that he give up a toy willingly For this reason the test must be given rather late in the testing period and always with a smile.

X 6 Glass Plate Tests. This was correctly done by few children and their procedure was never that described by Buhler as normal. They usually pulled the glass forward and reached over it for the toy. Any toy in which the child had shown marked interest was used behind the glass.

X 8 Memory Test. Like McGraw (10) we found five minutes too long a time to expect the child to play with box and ball He was kept interested in the box for as long as two minutes. Since both tests *X* 8 and *XI* 3 (the memory test with a longer interval) had to be given to the same children the question arose as to whether if *X* 8 were passed the box and ball should be presented again together in preparation for the ten-minute interval of *XI* 3 This same question arose in connection with the memory tests at the higher levels *XII* 6 and 7, *XV* 7 and 8, *XVIII* 6 and 7 and *XXI* 6 and 7 To give the memory tests fairly at the first level at which each appeared one must test the child's memory after the shortest interval. If he passes it at this level, one must in fairness at the next higher level present the complete stimulus (box with ball in it) again and then wait the next longer interval But by presenting the stimulus again one adds to its value by summation and undoubtedly therefore adds to its memory value. The instructions for the memory tests do not clear up the dilemma, so we gave each

test in order, presenting the complete stimulus before each memory period For some bright children of 12 months this meant that they saw the box with ball in it four times at ever increasing intervals.

X 10 Opening a Box This test is easily done by the child through sheer accident if he manipulates or bangs the box at all The cover is loose enough to fall off In the absence of any definite criterion of his intention to open the box these apparently accidental openings had to be credited

XI 5 Imitating Sounds If the child's vocalizations could not be elicited here the mother's spontaneous report of syllables said at home was given credit.

XI 6 Fear of the Unfamiliar. We usually used the chicken in the ball as stimulus for this test Buhler suggests either a new toy, a strange person, or a strange situation. We selected the toy as being more standard, since the three kinds of stimuli she suggests are not comparable and probably have less similar values for different children than an unfamiliar toy would have.

XI 7 Pulling an Object by its String. For this test the string was placed near the child's hand, never in it, although Buhler suggests this alternative.

XI 9 Fitting Hollow Blocks into One Another and *XII* 10, Taking a Nest of Blocks Apart and Putting Them Together Again. The distinction between these two tests is not clear For both levels the nest of blocks is taken apart and placed before the child The examiner does not show how they are to be put together For the 11-month test "The child puts the blocks together again, fitting the smaller ones into the larger" (3, p 238). For the 12-month test the examiner observes the child for five minutes and he is credited with success if he "puts one block into another and takes it out again at least once during the period of five minutes" (3, p 244). This seems to make the 12-month success easier to obtain than the 11-month success We kept a written record of exactly what each child did with the blocks No child even as old as 20 months put all the blocks together again, in fact no child had more than three of the five together at any one time so the 11-month criterion seems to be too difficult The 12-month criterion was passed by two of the eighteen-month children, by three of the ten eleven-month children, by four of the five 13-month children, by all children older than thirteen months except one 15-month child with a developmental age of

thirteen and a half months, and a very much inhibited 20-month child. Although our cases are too few to use as a basis for definite standardization these results suggest that the 12-month criterion of one block into another during the five-minute period is probably fair to children of 12 months In our study the test was credited at both levels if the 12-month criterion was passed.

Crediting the test this way makes a child receive two credits for only one test. We have carefully studied the record of the responses made to this test in the hope of finding other possible discriminative criteria for it. At all ages from eight months up, banging occurred along with the fitting of blocks into each other, so this behavior is not discriminative. Those children who fitted alternate sizes into each other also did the harder manipulative stunt of fitting consecutive sizes into each other, so these two types of response are not discriminative. Piling two blocks on each other seems to begin rather suddenly at the age of 14 months or the developmental age of 16 months, so such a test might be appropriate in the 15-month group of tests We found no method of scoring the blocks that seemed to be discriminative as a substitute for the test at 11 months.

XII 1 Organized Play· Getting up and Lying down. This test aroused some negativism, partly because children of this age seemed to object to being in the lying position even for a moment and partly because they all objected to the slight coercion used to demonstrate the "game."

All the walking and standing tests were given on the floor if they were not passed in the crib, because the crib mattress gave so difficult a walking surface. These tests were better elicited by mother than by examiner.

XII 5 Grasping at the Reflection of a Cracker in the Mirror. We used a small, ¾-inch ball instead of a cracker as the stimulus It is difficult to determine whether the spot the child reaches for in the mirror is where the reflection of the ball is, because of course the spot where the reflection of the ball is seen is different for the examiner than it is for the child There is a question as to whether the child is just patting his own image as in *XII* 4 (Observing His Image in the Mirror) rather than reaching for the ball

XII 7 Recalling the Chicken. This test, Buhler says, is to be given before XII 8 Imitating Squeezing the Ball to Make the Chicken Come out. It seemed to us that this was a needless precaution because

the same memory test given at higher levels has to come after imitating squeezing the ball anyway. In fact, having the memory tests follow squeezing the ball seemed preferable because if the child knows how to push the chicken out his memory response is more easily scored; there is a definite activity, squeezing, as the criterion of memory, rather than just the decision as to whether he "looks questioningly."

XVIII 1 Understanding a Forbidding. It is recommended by Buhler that the child and examiner be engaged in play for "five to ten minutes" before the toy to be forbidden is introduced. In our work we utilized the previous testing period and while the child was engaged in playing with blocks, drum, sticks, or some other toy, the examiner manipulated another toy The toy chosen should be one that the child has not been playing with before or the forbidding will have no point, it must be one the child is not allowed to play with later or he is likely to show hesitation in playing with it later We used a toy like the rubber doll that was intended for earlier age levels but was still interesting to this age.

XVIII 3 Climbing. For this test we used a nursery school chair with the seat eight inches from the floor The child held either the back of the chair or the crib for support

XVIII 5 Finding and Taking a Cracker from under One of Two Boxes. Here again we used a small ball (different from the one used in the memory tests) instead of the cracker. The criterion of success is said by Buhler to be the passing of three trials Whether this is three of three trials, three of four, or three of five is not stated. We credited only three consecutive initial successes.

XVIII 10 Respecting the Work of Another. The directions do not state how long the child should observe the tower. We credited the test if he observed it a moment even if then he tore it down

XXI 5 Putting a Watch to his Ear upon Command. Instead of using the words "Where is the tick-tock?" to get the child to put the watch to his own ear we used the words "You hear the tick-tock" The watch was tied on a long string one end of which the examiner held.

XXI 9 Fitting Two Hollow Sticks into One Another The two hollow sticks provided would not fit together, so we credited merely the attempt to fit them together

XXI 10 Placing Blocks on Top of One Another. The criterion for success with the blocks at this age is "The child places at least

two blocks on top of one another during a period of five minutes" (3, p 254). We were not sure whether this meant one block on top of one or two blocks on top of one, making a pile of three. A record was kept of exactly what each child did with the blocks One child at nine months, one at 11 months, seven of 12 children at 12 months, and one or more at nearly every month level above that, piled one block on another at some time during their play. We gave no test to any child over 20 months of age. We conclude from these results, and also from the fact that the Merrill Palmer scale demands the piling of three blocks imitatively at 18 months, that the correct scoring for this test is three blocks in a pile We used this criterion and scored piles of two blocks only as failures.

From the meager data collected in this study for children of each month level on the tests of that level alone (six to 12 children) no definite statements as to the placement of individual test items are justified We found several tests which were passed by all children of their month level and some passed by no child of their month level A full study of the placement of these items will have to await the testing of more infants.

Evaluation of the Scale as a Whole

The Bühler scale for the first and second years of life was selected for this study for several reasons. It contained many single test items for each test level. Its ratings were in terms of developmental ages which are easily comprehensible to lay persons. The lack of rigidity of its standardization and the freedom permitted in the testing procedure were considered to be an advantage in applying the tests clinically It was desired to learn how reliable and valid the measures of a child's ability could be, when obtained under such comparatively informal circumstances.

In administering the scale we have found several disadvantages in its makeup. The perishable, non-washable materials are a handicap, especially when they come from the distance of another country

There seem to be many frustrations, obstacles placed in the child's way or toys in which he has become interested withdrawn, to observe his method of adapting to them Each frustration arouses the child's anger or other negative reaction and makes the test difficult to give. The Bühler scale was compared in this respect with the three other

best known infant scales. Of 115 items in the University of California scale for infants (1), nine are frustrations; of 64 items in the two series of the Linfert-Hierholzer scale, four are frustrations; of the 186 items of the Gesell scale that are used for testing the first two years (6), 10 are frustrations. Of 140 items in the Buhler scale, 27 are frustrations. This scale, then, has more than twice as high a percentage of frustrations as any of the other scales.

The wide scatter of children's successes is a disadvantage inasmuch as it forces the lengthening of the testing period. No doubt, as the scale is used more, tests that may be slightly misplaced at present will be re-allocated and any scatter due to this cause thereby eliminated.

The very freedom allowed in the administration of the scale is a handicap in that one can never be sure he is following instructions sufficiently closely. The scale is not at this point a scientific technique but leaves much leeway for subjective judgment. In view of this characteristic of the scale, the good statistical results obtained with its use are surprising.

In spite of these disadvantages, this study of the scale and its probable reliability and validity as indicated by the testing done on this relatively small group of children suggests that the scale is well worth the effort of a thorough standardization.

Summary

The Bühler Infant Scale was used in testing 78 infants from the Well Baby Clinic of the hospital. The babies returned for retests, at intervals averaging four months in length.

The retest reliability coefficient for 44 cases, first versus second test, was $.70 \pm .05$. There were changes as great as -19 or $+46$ points in developmental quotients on retests of some individual children, and ratings obtained on second tests were more reliable than those obtained on first tests. Ratings seem to be fairly reliable but for individual predictions at least two tests should be given.

The Merrill Palmer scale was administered to these children as they became old enough. First-test ratings of 25 children on the Buhler scale agreed with their ratings on the Merrill Palmer to the extent of a correlation of $.37 \pm .11$, second-test ratings of 15 children agreed with their Merrill Palmer test ratings to the extent of a correlation of $.70 \pm .09$. When corrected for attenuation these cor-

relations became .52 and .99 There is more agreement between ratings on this scale and on the Merrill Palmer than has been reported between the ratings of any other infant scale and a pre-school test.

The average developmental quotients for these children from marginal and dependent homes were "high average" or "superior," suggesting that the scale may be too easy for children of the general population There are indications that the group used for this study were actually above the average for their economic level The adequacy of the standardization of the scale can be tested only by studying a large and representative sampling of infants from all levels

Disadvantages of the scale here mentioned were the wide scatter of successes necessitating a testing period of an hour in many cases, the hiatus of a month between the eleven- and twelve-month levels for which no tests are provided, the number of frustrations in the series, and the inadequate standardization of administration and scoring

Specific procedures were here described for some tests whose original instructions were equivocal

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UNE ÉTUDE DE LA CONSTANCE ET DE LA VALIDITÉ DE L'ÉCHELLE DE BÜHLER POUR LES ENFANTS

(Résumé)

On a employé l'Echelle de Buhler pour les Enfants pour tester et tester de nouveau 78 enfants La constance du nouveau test dans 44 cas, le premier test comparé au second, a été de 0,70 mais de grands changements des quotients de développement se sont montrés dans les nouveaux tests de quelques enfants individuels, ce qui suggère la necessité de deux tests avant qu'on fasse des prédictions individuelles

Les évaluations de 25 enfants dans le premier test sur l'échelle de Buhler ont donné une corrélation de 0,37 avec leurs évaluations Merrill Palmer, les évaluations de 15 enfants dans le second test ont donné une corrélation de 0,70 avec leurs évaluations Merrill Palmer Ces corrélations représentent un plus proche accord qu'on n'a rapporté entre les évaluations de n'importe quelle autre échelle pour les enfants et un test pré-scolaire

Les quotients moyens de développement pour ces enfants de familles marginales et dépendantes ont été "moyens supérieurs" ou "supérieurs," ce qui suggère que l'échelle peut être trop facile pour les enfants de la population générale Il y a des indications que le groupe employé dans cette étude a été vraiment au-dessus de la moyenne pour leur niveau économique On ne peut tester la suffisance de la standardisation de l'échelle qu'au moyen d'étudier un échantillon grand et représentatif des enfants de tous les niveaux

On a discuté les inconvénients de l'échelle et les processus pour les tests spéciaux.

HUBBARD

EINE UNTERSUCHUNG DER ZUVERLÄSSIGKEIT UND GÜLTIGKEIT DER BÜHLER KINDERSKALA

(Referat)

Die Bühler Kinderskala wurde bei der Prüfung und Wiederprüfung 78 kleiner Kinder angewandt. Die Wiederprüfungszuverlässigkeit für 44 Fälle, der erste gegen den zweiten Test, war 0,70, aber es gab grosse Änderungen der Entwicklungsquotienten bei Wiederprüfungen von einigen Kindern, was darauf hinweist, dass die Notwendigkeit für zwei Tests besteht, bevor einzelne Vorhersagungen gemacht werden können.

Die Werte des ersten Tests der 25 Kinder auf der Bühler Skala korrelierten 0,37 mit den Merrill Palmer Werten, die Werte des zweiten Tests der 15 Kinder korrelierten 0,70 mit den Merrill Palmer Werten. Diese Korrelationen weisen eine engere Übereinstimmung als zwischen den Werten irgendeiner anderen Kinderskala und einem vorschulpflichtigen Test auf.

Die durchschnittlichen Entwicklungsquotienten für diese Kinder aus schlechten und abhängigen Familien waren "hoher Durchschnitt" oder "Überlegen," was darauf hinweist, dass die Skala zu leicht für Kinder der allgemeinen Bevölkerung sein mag. Es gab Andeutungen, dass die Gruppe in dieser Untersuchung tatsächlich über dem Durchschnitt für ihr ökonomisches Niveau stand. Die Zulänglichkeit der Standardisierung der Skala kann nur durch die Untersuchung grösser und vorstellender Gruppen von kleinen Kindern aus allen Niveaus nachgeprüft werden.

Die Nachteile der Skala und die Verfahren für besondere Tests werden erörtert.

HUBBARD

THE SOCIAL AND PSYCHOLOGICAL SIGNIFICANCE OF GESTURES (A DIFFERENTIAL ANALYSIS)*

From the Chicago City Junior Colleges

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The first step in the analysis of any problem is a definition of terms The most important term, for our purposes, being *gesture*, we shall attempt to define that first From everyday observation we know that gestures are quick, sudden movements, and that they bear a certain kind of relationship to all other types of movement. Merely designating a gesture as a spontaneous movement is not to define it, however. Every movement begins somewhere, increases in intensity (however imperceptibly it may do so), shows a diminution of velocity, and either becomes wholly blocked or deviates from the original direction and passes into some other type of movement.

Movement is continuous, and the singling out of gestures is not an easy matter. Tentatively, however, we may agree to define the term *gesture* as a sharp and quick change in the spatial adjustment of the organism, beginning with a given postural set, or reduced velocity state, at any given time Thus conceived, it may be studied with reference to an intra-organic or extra-organic situation. In other words, when a gesture is differentiated from movement-in-general by the emphasis placed on the *mode of change* in the spatial adjustment of the organism, and its relation to a corresponding change in the existing situation, it becomes a unit of behavior which may be studied by the methods of objective psychology.

I. PRENATAL MOVEMENTS

If gestures may be said to exist as muscle movements, they may also be said to be muscular adjustment patterns They are found in living organisms very soon after the stage of fertilization, and they play an important role in the adjustments of the embryo A recent study by Gonzales (8), based on the prenatal development of over a thousand rat fetuses, reports typical intra-uterine move-

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ments, starting at the age of 14, and ending at the age of 20, days. The movements were recorded by a motion-picture camera directly, with stenographic aid, the fetuses being maintained under optimum physiological conditions.

The study of rodents does not give us definite knowledge as to the development of the human fetus. Among the phylogenetic differences, differences in gestation period are probably the most important. *An equally systematic study of human fetuses is, of course,* impossible, but some work has already been done to indicate probable trends. Minkowski (16) studied human fetuses removed by Caesarian section at the age of two months. Mouth movements (lowering and lifting of chin) appeared as early as the third month of prenatal life. By the fifth month the movements were quite definite. Thermal, tactile, kinesthetic, and deep pressure stimuli were found to be effective. Combining the studies of Minkowski with those of Bersot, Bolaffio, and Artom, covering a total of some 50 human fetuses, Coghill (4) recorded the intra-uterine reactions for fetuses of different sizes.

The studies of human and infra-human fetuses alike have brought out the fact that complex behavior is not achieved by the gradual summation of separate action units but by the expansion of an integrated organism, from which partial patterns gradually emerge to become independent of the organism as a whole. Under normal conditions, the supremacy of the organism over these partial patterns is continuous, and never ceases. Coghill holds that abnormality or perversion of behavior consists of an inappropriate degree of independence on the part of one segment of the organism or of one type of adjustment mechanism. Indeed, impairment of the nervous system, whether experimental or pathological, proves this by accentuating independent functions, and bringing subsidiary mechanisms into a position of relative dominance over the entire organism.

To say that the differentiation of movements is abnormal, however, is not to say that the development of specific function by a sort of analytic process is necessarily abnormal The differentiation of movements from an integrated total movement pattern is indeed the most striking finding of those who studied fetal behavior. As the integrated pattern expands, individuated movement patterns must come into play. Sherrington (20) long ago emphasized the presence of separate reflex movements, and Coghill (4) laid stress on the fact

that total movements are present at the beginning and that others become differentiated from them. But it was left to Kuo (13) to *explain that differentiation takes place because total responses must* become reorganized when they fail to meet new conditions, i.e., fail to adjust the organism. When intra-uterine conditions become so complex that the organism can no longer adjust itself on some previous, *simpler basis, then differentiation, or the creation of new* behavior units, presents the only way out of the difficulty.

This, however, is a temporary matter. Gonzales (8) points out that individuation of action patterns is not achieved through the *breaking-up of total patterns but by an inhibitory process, whereby* the primary or basic movements are arrested and individuated patterns are released. The total patterns remain latent until, in time of recurrent stress, they may be revoked by proper stimulation. In *other words, the organism retains its ability to act as a unit;* so much so that even when the simplest individuated reflex pattern is in evidence, the total pattern still definitely dominates the movement (7). A permanent replacement of total patterns by separate patterns *occurs only in pathological cases. Normally it is found in cases of* temporary readjustment, before the realignment of patterns on a new basis has taken place. Normally, in any case, separate patterns do not dominate but, instead, are dominated by, the total organismic patterns.

II. Infantile Gestures

Whatever is characteristic of the fetus is also characteristic of the newborn, except that, in the latter, the differentiation of total patterns proceeds more rapidly. For differentiation is a function of environment, and increases in proportion to increased complexity of stimulation.

Most of the differentiated patterns of the neonate can be shown to be definite adjustment patterns. Let us take yawning, for example. One physiological explanation is that yawning begins with fatigue toxins generated in strained muscles, which cause cramplike pains (14). A yawn, by forcing blood out of the veins of the neck into the general circulation, removes the toxins through the organs of elimination. In sleep, neither animals nor human beings yawn, because, with the body in a horizontal position and the neck muscles

relaxed, the heart can supply one part of the body as easily as another. A yawning spasm may, however, grip the individual, whether human or sub-human, on awakening.

Another possible physiological interpretation of yawning ascribes this reaction to well-known pressures in the circulatory system itself (17). According to this view, yawning is found in fatigued individuals because their lower respiratory rate diminishes their oxygen intake. To the gaping of the mouth in yawning this theory ascribes an evolutionary significance, for fish open their mouths to pass more water through the gills, and thus to get more oxygen. This respiratory theory merges into the previous circulatory theory, and both point in the same general direction

These interpretations illustrate the adjustive significance of certain reflex acts, and indicate that individuated reflexes come into action when the organism can not otherwise meet the exigencies of its existence. Thus the process of differentiation continues through the *post-natal period very much as it had begun in the prenatal setting* In the latter the trend of development is from gross totality to relative totality, from complete integration to integrated specialization. This remains the general trend of development throughout. Gross totality is probably never achieved again, and the problem of the organism is a problem in integration of differentiated patterns, rather than one of summation of patterns to one grand total

The problem of integration is a problem of consistency of differentiated movement patterns. This consistency of motor movements of animals, as Schwangart (19) has shown in a review of various relevant studies, and as Allport and Vernon (2) have recently shown in the case of human beings, is characteristically present to a noteworthy degree In other words, total organismic patterns are present regardless of the differentiation continuously taking place Some degree of inconsistency is, of course, also to be found in the behavior patterns of living organisms, for, even where growth is normal, previously conditioned patterns continue to manifest themselves *without being necessarily representative of the total organism*—that is to say, without being related to all the conditioned patterns acquired in later life or being adaptive to the organism's environment

It is for this reason that much of the behavior of the child, and especially of the infant, is synkinetic, that is, accompanied by all

kinds of accessory or random movements. Physiologists have generally ascribed these movements to an overflow of energy as a by-product of metabolism. That perhaps explains why these reaction-patterns are as varied as they generally are. It does not, however, explain why most of them gradually disappear, while some of them, like tics, are often slow in disappearing. The oft-quoted case of Preyer (18) is an illustration in point. It deals with a child who, having for some time used his hands to relieve an annoying itch, continued, after his eczema had healed and disappeared, to scratch every time he met a disagreeable situation. Adams (1) reported the case of a seven-year old, who usually sucked his thumb when tired and sleepy (itself an accessory movement), but was noticed to do so also when he had failed in some effort The writer has observed children grasp and manipulate their genitals when obstructed in some task which they had undertaken, or, when refused some request which they had made Crying is generally a part of this adjustment pattern.

These patterns are, clearly, *vestigial adjustments* going back to a preceding stage In the transition from the prenatal to the post-natal environment, and from one form of post-natal development to another, the infant and the child may continue with differentiated patterns of behavior which had been carried over, without complete inhibition, from an earlier adjustment stage. In fact, it may be stated as a rule that, insofar as these differentiated patterns continue, the individual is not free from early ties In a sense, then, they are a test of the motor achievement of the individual

III. The Gestures of a Feral Man

The rapidity with which the individual acquires his movement patterns, and the degree of consistency between them depend, in large measure, on the environmental setting in which the individual grows up. For it is the environment which not only conditions the formation of new adjustment patterns, but effectually inhibits those which, serviceable in an earlier setting, have since lost their adjustment potency

A human infant generally grows up in a social environment and, willy-nilly, becomes an exponent of the cultural milieu into which he has been born and from which he has derived his postnatal

adjustment patterns What of the motor patterns of an infant or young child who is deprived of human culture? The answer can be based on the known cases of feral man, one of whom—the Wild Boy of Aveyron—has come to be especially well known through the memoir left by Itard (10).

For one thing, Itard records that the Wild Boy, whom he had named Victor, was "destitute of all means of communication and attached neither expression nor intention to his gestures or to the movements of his body" (10, p 6). When he first came to know the Wild Boy, Itard found him manifesting a number of spasmodic movements bordering on convulsions Most of the time Victor was engaged in ceaseless swaying back and forth "like certain animals in the menagerie" (10, p. 4).

Shortly afterwards Itard discovered that Victor was devoid of the usual sensory-motor reflexes. For example, sneezing could at first be evoked only after "the most energetic stimulation, and sometimes by intense emotion" (10, p. 19). Later, Itard records, "the least irritation of this organ [the nose] provoked sneezing, and I judged," he adds, "by the fright that seized him the first time it happened that this was a new experience to him He immediately ran away and threw himself on his bed" (10, p 30). Even so common an infantile pattern as sneezing evidently had no place in an environment which had not facilitated its use.

Gradually Itard succeeded in socializing Victor to the point where the boy began to babble. Babbling was generally accompanied by numerous reflex acts, such as coughing, sneezing, and crying, the latter particularly being considered by Itard "expedient for the simultaneous development of the organs of respiration, voice, and speech" (10, p 30).

Even less understandable automatisms occurred and were recorded with the fidelity of the scientist that Itard was When Victor was forced to push or carry anything, he was as likely as not suddenly to abandon it, "though it was neither hard nor heavy," in order "to look at the ends of his fingers which were certainly neither bruised nor hurt, after which he would put his hand gently in the opening of his waist-coat" (10, pp. 18-19).

Itard's own explanation was that this "childish play" was a demand for those "maternal triflings" which call forth "emotional responses" in the young, and which Victor presumably was trying

to obtain from his preceptor This explanation appears to be only partially correct, however, for we do not characteristically associate all the movements listed with the fondling process The value of this and other passages, therefore, must be taken to lie not so much in the interpretations essayed by the writer as in the accuracy of his observations depicting the sensory-motor development of a child in a non-social environment. The interpretations, as now seen, are best given in terms of differentiation and integration of action patterns.

Differentiation from a fundamental total pattern presupposes the assimilation of differentiated patterns to the end that the organism may act with some degree of consistency That lacking, the differentiated patterns are left dangling, that is to say unintegrated into the total organism, but, nevertheless, capable of dominating it in the strange ways recorded in this case. The unincorporated patterns of the Wild Boy were probably patterns which had been conditioned in the feral milieu, but were found to be more or less useless in the new habitat into which he happened to be drawn. Their recurrence under new conditions simply showed how powerfully they had been conditioned, how slow was their extinction in spite of their failure to meet at least the external demands of the environment, and how completely the organism might be dominated by vestigial patterns in spite of their failure to bring about adjustment.

Thus, whether viewed in the prenatal, the neonatal, or in what we might term the acultural, subject, the problem of unconventional gestures presents itself in much the same way. We find these gestures to be unconscious to the subject. We find them to be without meaning to the subject but, in the sense that they relieve existing tensions, rather obvious to the onlooker. We find that subjects of various species possess gesture patterns, in the stages under discussion, which represent movements differentiated, in the course of development, from the total organismic pattern, tending to become reintegrated into the selfsame pattern. Finally, we find these unconventional gestures to originate in the process of individuation demanded by increasingly complex stages of development.

IV. Conventional Gestures

In the post-natal development of a human individual the culture of his group looms large. Naturally, this means that his post-natal

gestures are, to a large extent, culturally conditioned. To say this is not to presume that, because certain behavior patterns exist in the culture of an individual, those patterns must, of necessity, become the property of every individual in that culture. Such a presumption would imply that there is a point-to-point correspondence between individual and cultural phenomena No such correspondence exists

Strictly speaking, individual behavior patterns and institutional patterns can not be compared. They can not be compared because they presuppose each other and, by various imperceptible ways, enter *into each* other's makeup. If there is such an entity as a biological organism free from cultural influence, we can best see it in the famous Itard case. Aside from such anomalies, and excepting vegetating idiots incapable of communication, we do not know what a human being might be without cultural influence If there is, on the other hand, such an entity as group culture devoid of individual participation, we can not tell what it is, except in the esoteric sense in which we speak of culture as a continuity independent of any one man's contribution

What we do know is that human individuals forever act in terms of these inter-personal situations which they have met and to which they have somehow reacted The social situations, in turn, we know to be determined by those reaction patterns of others, previously *manifested and frequently repeated, which we call institutional* behavior patterns. The scheme of cultural conditioning runs somewhat as follows Pre-existing institutional patterns, unavoidable for human individuals, and preliminary to each instance of interpersonal contact, define, or become verbally conditioned, in the presence of human individuals, thus converting a mere aggregation of human beings into a social situation, in which individuals act in accordance with the verbal interpretation of the existing situation Every response in a social situation means conditioning of the individual's behavior-patterns, and is thus the occasion for the formation of his personal habits. In this way the culture of the group affects individual behavior, but this, it will be noticed, is far from creating a point-to-point correspondence between individual behavior and culture forms.

As a means to personal organization, in the sense described, the cultural milieu is an agency facilitating the formation of the indi-

vidual's movement patterns. Culture, as said previously, does not impose itself on the individual in the sense that it *makes* him do something. Neither does it literally penetrate his skin and become part of his organism. Culture merely represents the aggregate of patterns which most members of a given group actually manifest. These patterns were once adjustment patterns which grew out of individual conflict situations. Conventionally standardized gestures are one type of cultural pattern. In the numerous instances in which they are used we shall espy persistent signs of conflict. In the forms which they take we shall, hence, find the earmarks of *symbolic* adjustment. Let us turn to these gestures.

Darwin (5) was among the first to remark that certain types of expressive movement are to be found the world over, various so-called racial groups showing remarkable similarity, though by no means identity, in regard to those movements. He called attention especially to the shaking of the head as signifying negation and to nodding as a mode of affirmation. It is well known that such similarity exists in the language-signs of deaf-mutes the world over, who, without much difficulty, can understand each other, in spite of linguistic differences.

A gesture is a silent word. Speech and gesture are of equally primitive origin. Both are subordinate to thought and prior to it. In spite of the existence of certain overlapping symbolic forms of expression, however, the majority of the language systems and motor patterns of the peoples of the world remain as distinct as are their intellectual-orientation systems. The intelligibility of the symbols of one group to the members of another is predicated upon the transfer of meanings based on those facts, objects, and relations which constitute the irreducible minimum of social intercourse. Beyond this, a one-to-one correspondence is rare, if not impossible. The symbols of trappist monks vowed to silence, the secret signs of the Neapolitans of Italy, and of others of a local order, represent systems which are one-to-one equivalences of the normal systems of speech used in the cultures of these people, and, like the latter, are largely different from those of any other group.

Many preliterate peoples have gesture languages. Some of them, like the Kurani of Southeast Australia, have never used it. Ethnologists have estimated, however, that there were over 100,000 Indians who have used sign-languages at one time (9). The Indians

had gesture language developed to a point of considerable complexity, the Cheyennes alone having elaborated a sign-language of 7000 symbols (14). These languages involved the use of the arms and hands primarily Pointing to an organ often meant to refer to that organ symbolically, but sometimes also literally, depending on other elements included. By means of their signs, Indians of vastly different tribes have been able to communicate without difficulty, a fact *of great significance in the history of both the Indians and the* American colonists

Many and various are the forms of symbolic expression and communication among human beings. The ancients used cryptograms and hieroglyphs. Semaphore codes are highly technical and highly standardized, though also thoroughly artificial, systems of signs. Stock and grain markets use figures, alphabets, and phrases expressed through arm and hand gestures, for speed in communication. Ideographs and pictographs employed by Indians, vagabonds and yeggmen, gypsies, trappers, scouts, and hunters (the latter in marking trails), are all well known

The use of standard gestures in codes, languages, and systems of these kinds depends on highly artificial symbolic arrangements, the origin of which is relatively easily traced to their historical fountainheads. The standardized modes of communication and control which cultures of various types possess, those gesture forms which are less understood than practiced, less traceable to their source than useful in the organized life of human beings, are more important for our purposes than are all others, with the possible exception of sign languages

Conventional gestures could be said to comprise other behavior forms implied in the term *social etiquette,* such as buttering bread, cutting meat (which, in our culture, consists of some twelve or fourteen distinct motor-movements), squeezing lemons, sucking lollypops, picking teeth, using handkerchiefs, etc *Religious ceremonials* incorporate a great many gestural patterns: crossing the hands on one's chest, in Hindu prayer; bringing the hands together before one's face in Christian prayer; or superimposing the hands in front of the abdomen, in the case of Catholic priests *Legalistic ceremonials* could be used to demonstrate the same type of gesturing. Illustrations in point are tipping one's hat to a flag, or the recently developed fascist salute. *Professional activity* includes a good deal

of gesturing, witness the movements of the machinist, the musician, the file clerk, the singer, the teacher, the medical man *Games* and *pastimes* certainly demonstrate numerous types of gestures and postures, viz., tennis, golf, baseball, disc-throwing, etc.

V Pseudo-Conventional Gestures

Perhaps the best proof in favor of the cultural origin of the motor movements listed here is the fact that, in our culture and in many others, there have been men and women who have made the reproduction of characteristic gestures their temporary or permanent vocation. The Athenian sage, Xanthus, who had studied the art of public speaking and taught it to others, also had rules of delivery which had reference to gestures These gestures, of course, were standardized movements which were presumed to effect certain responses in the audience

Xanthus' advice as to moderation and grace in gesture indicates of course the probability of common cultural background in audience and speaker In addition to this, the production of these *pseudo-conventional* gestures seems to be contingent on two individual factors. first, the ability to introject and reproduce the attitudes and habits of those who are being mimicked, and, second, an anticipatory posture based on past observation and referring to the probable response of the onlooker. Artists of the stage and screen, of course, represent this calling at its best. However, we find the hardened criminal "acting" the innocent lamb, the murderer of an important public official "acting" the martyr, the self-confessed hero posing for newspapermen, the grafting politician smiling benevolently upon his audience, etc. These posed, or pseudo-conventional, gestures are marginal to the other gestures, determined by the cultural setting in the normal processes of social life, but they, too, are important.

Of course, the success of one's posings, in these cases—and this applies to stock actors as well as to "amateurs"—depends on the correctness and completeness of the observations made. Recently, for example, a certain moving-picture actress posed for a newspaper, demonstrating what she considered to be characteristic leg postures of women, and attempted to verbalize their meaning Since the gestures with which she was concerned were not—through cultural patterning—recognized by all the members of the group, her demon-

strations could neither be contraverted nor accepted. The fact that the actress had to demonstrate and label the gestures proved the lack of conventional acceptance of their symbolic connotations. Insofar as the verification of the gestures through the previous conditioning of the hypothetical average citizen seemed questionable, her attempt fell short of accomplishing its purpose as interpretative dancing.

Somewhat different are the "talking hand" gestures of the Hindu dancer, Menaka, who has recently received considerable publicity. This dancer purports to introduce to Westerners the ancient, classical dances of old India, which she terms *nrtya* dances. Menaka has stated that her hand movements are not merely accompaniments to the beating of drums, "but visual poetry in which every posture of the hand has dramatic and definite significance" These hand gestures are adapted to the understanding of the natives of India, though not that of Hindus who have lost contact with their ancient religious dances, and thus can no longer "penetrate into the symbolic meanings of her movements"

"In India," Menaka says, "every nautch girl who would dance as many generations of her people have danced before her, is to learn a veritable dictionary of gestures. There are thousands of them, and every one means something definite and different, just as the letters of the alphabet arranged in words do" To Menaka herself there are no less than twenty meanings expressed by the extended fingers of the closed hand alone "These meanings," she says, "are conveyed by the manner in which the hand is held, or moved, and by comparing each position with preceding and following positions."[1]

The important fact, for our purposes, is that this hand-talking is not casual and is understood, or presumably understood, by the dancer's audience. She feels that she is not a prima ballerina, inventing esthetic configurations for entertainment purposes, but, as she says, a "medium of expression" This type of dancing evidently is different from that of the dancer previously mentioned, who does not concede cultural significance to the postures she enacts, but,

[1]The references to Menaka are quoted, by permission, from the *American Weekly*, Inc, of July 22, 1934.

rather, claims special insight and achievement in her discovery. Both this and the other type of dancing, however, may be placed under the general classification of pseudo-conventional gestures.

The pseudo-conventional gesture is thus learned in specific personal situations. It is vividly conscious to the actor, and undoubtedly has meaning to him. It is, furthermore, supposedly understood by the observer, though whether it actually is or not depends on the ability of the actor to anticipate the responses of others. This gesture is similar to that produced by special types of cultural situations, and, as such, may be regarded as at least temporarily integrated into a total personality structure. The origin of pseudo-conventional gestures lies in the process of vicarious adjustment to difficult personal problems often symbolized in such a way as to obscure the motivation involved.

VI. The Meaning of Conventional Gestures

If words are auditory pictures, gestures are visual sounds. Visual-sound patterns are not determined in the same way as ordinary institutional patterns. Herbert Spencer has shown that, before sacred and secular regulations arose, there had been those vague forms of social control which he called "ceremonial," and which, even after the rise of ecclesiastical and political authority, continued to shape and direct human conduct. "The earliest kind of government, the most general kind of government, and the government which is *spontaneously recommencing, is the government of ceremonial observance*," said Spencer (21). Ceremonial observance Spencer attributed not to authority, which itself would presuppose organization of some kind, but to the modification of acts, as he says, "performed for personal ends." For example, the Tasmanians, devoid of government, except that implied in leadership in time of war, and Esquimaux, who do not have anything like chieftainships, have definite techniques for symbolizing preferences, defiance, propitiation, and other types of inter-personal adjustment.

Groups begin with certain total patterns—that is to say, with certain consistent schemes of inter-individual adjustment. Gradually there spring up various gestures which are not consistent with the major, prevailing, patterns of the group. So pervasive are these

gestures, as Spencer pointed out, that even total patterns, like ecclesiastical and governmental institutions, do not supplant, though they sometimes absorb, these gestures or "ceremonials" The conventional gestures which we have been discussing are thus left-over adjustment techniques which persist in spite of the total patterns evolved by the group. In this way they parallel the vestigial patterns found in the early stages of individual development

Spencer's theory, as thus interpreted, does not give us any cues to the mechanics of differentiation That is to say, it does not explain how the total social patterns become differentiated into partial patterns which linger in social life because they find applicability *in conflict situations in which individuals fall back on older methods* of adjustment. Dashiell (6) has offered a plausible analysis of the mechanics of differentiation in social patterns.

Whenever an impulse of an individual, he says, becomes obstructed by the act of another individual, so that the individual can not freely operate, the response of the first individual must be an abridged one. In other words, the total pattern can not operate at all where it can not operate effectively, and differentiation is indicated. The other individual, having learned to interpret the perceived reaction, readjusts his behavior, thus making it possible for the first individual to fixate the partial response as an adequate adjustment for all similar future situations.

Spencer has shown that partial patterns exist alongside total group patterns, and continue to function for a long time, automatically renewing themselves, and evidently unaffected even by such powerful trends toward integration as modern institutional forms have introduced. Dashiell and others have reinforced Spencer's position by showing that partial patterns—that is to say, conventional gestures—are conditioned in conflict situations, in which the function of the entire pattern is impossible If the history of the original situation in which the differentiation of the total pattern occurred could be traced in the case of each gesture, we might have a natural history of conventional gestures for each culture group The development of the soldier's salute might serve as an illustration The process in this case appears to have been as follows:

Being struck down

↓

Prostration (falling, face down)

↓

Crouching

↓

Genuflection

↓

"Curtseying"

↓

Bowing

↓

Nodding head

↓

Lifting hat

↓

Tipping hat

↓

Touching hat

↓

Soldier's salute

The reasonableness of this analysis is confirmed by the officer's return salute, often in the form of a mere raising of the hand, which means: Rise![2] It may be argued that this does not represent a developmental account, in that the "stages" are relative to different situations But that is precisely the point. There is a gradual abbreviation of the original response, changing with the change in the situation demanding adjustment, for each of the "stages" given had grown out of a different type of social situation. So different are the successive situations here that less and less of the original situation comes to be symbolized in the gestural response. This then confirms the viewpoint adopted by us in regard to the vestigial nature of the gestures.

The function of the conventional gesture is economy of effort, since it always takes the place of another, more extended, form of response The symbolic reference of this type of gesture is not so obscure that it can not be traced Given adequate resources, in the way of historico-cultural material, we can infer the original situations which had called the gesture forth

Conventional gestures, including gesture languages, symbolic codes, customary and institutional patterns, are evidently acquired by the individual in the process of acculturation. They are conscious or semiconscious (that is, easily capable of becoming conscious) to the subject, and always have some meaning (in terms of aim or direction) to him. They are similar to the gestures of other subjects in the same cultural situation, and are thus specialized forms of adjustment, relative to the entire social structure of the group Conventional gestures apparently have originated in the processes of social conflict and accommodation to a more intensive form of cultural existence.

Because conventional gestures are directly perceived, recognized, and understood, they differ from all other types of gestures They are social gestures, in a somewhat exclusive sense, since their sequels are always clearly foreseen by both actor and observer, and behavior following them obviously implies their existence. Because they possess high utility in the field of inter-stimulation and response,

[2]Army men are taught that the salute is a mode of address which originated in the age of knighthood when the visor was lifted in the presence of a friend While the essence of our interpretation is not affected by this approach, yet the analysis here employed appears to the writer more fundamental.

conventional gestures have great survival value, and represent some of the most stable of gestural responses

VII The Problem of Autistic Gestures

It is well known that human individuals sometimes manifest gestural behavior which seems to have no definite meaning either for the subject or for the individual to whom the subject is responding At least, in terms of what precedes it we can not trace the stimulus, and, in terms of what follows it, we can not determine the direction of this type of behavior. Further, we know that it has no evident adjustment value, and that it is unlike all other types of gestural patterns

The same Xanthus who had recommended certain expressive movements in public speaking also recommended that speakers eliminate "certain imperfections" due to faulty training. Among the various imperfections he sought to eliminate were "useless gestures," which he defined as "gestures not required by the phrase, " viz , "All vulgar gestures , such as throwing the folds of the toga over the back or lifting them as high as the shoulder," "the hands on the hips, the fists in front, the hands crossed on the abdomen " All these, he said, were "indications of negligence and should never be permitted "

During a recent presidential campaign the wife of one of the candidates was present when someone delivered an address extolling her husband's virtues A newspaper reporter thus described her behavior, as seen off-stage:

> Mrs Y did not say one word during the speech She didn't make one motion, save, occasionally, to open and close her fan, and once to fix her black hair, with that mechanical gesture which women use when they are thinking of something else And when the words (name of her husband) closed the speech and started the tumult, all that Mrs. Y did was to shift in her chair and smooth the already smooth fold of her blue gown

A woman, accused of murder but denying her guilt, was interviewed by a newspaper-reporter who later wrote up the interview in this way:

> When asked point blank whether she knew the murderer, she *hesitated, placed her hands to her forehead, and also at times*

> covered her eyes, but—after a few seconds—she repeatedly said she did not know the murderer

A former president of the United States was reluctant to announce himself publicly on the candidacy of a certain nominee of his party. When he finally decided to emerge from obscurity to deliver an address in behalf of his party, he spoke calmly and earnestly of the achievements of the party, and when he reached the point at which he was to introduce Mr. Z., the nominee, he began: "The only man qualified for the high office is Mr Z.," at which point, as the movie close-up showed it, he quickly withdrew his handkerchief from a back-pocket, and blew his nose heartily, if not becomingly. As he continued, the following irrelevancies came into view. "What is best for our country," he said, and cleared his throat three times; then, "The issue that has come into this campaign," at which time he stopped to clear his throat two times, then, in similar fashion, on reaching the phrase "intelligent voting" he cleared his throat once. When he pronounced the phrase "have been revealed" he swallowed hard, and when he pleaded with the audience "to support Mr. Z for re-election" he gasped visibly.

It is not always that these gestures come in such brief, comparatively simple, automatisms. Often they may be observed in series of various types. Here are two records of observations recently made. A street car conductor calling a certain street is seen going through the following movements:

1. Strokes chin sideways with open palm
2. Shuts lips with finger
3. Wipes nose with finger

The time intervals between the gestures were approximately in the proportion of 3 3·1

A man observed on the street car dozes off, and every five minutes wakens with a start. The gestures observed, over a ten-minute period, are as follows.

1. Places two fingers into closed fist
2. Withdraws fingers
3. Replaces the two fingers in the fist
4. Places three fingers in the fist
5. Twists fist and fingers continuously
6. Withdraws the three fingers

7. Places two fingers in the fist
8. Quiet for a time, dozes off
9. Opens fist and adds third finger
10. Twists fist and fingers continuously
11. Withdraws three fingers
12. Places two fingers in the fist
13. Dozes off with two fingers inserted
14. Lets fingers slowly slide out of the fist
15. Wakens, and intertwines fingers of both hands

The observation discloses a certain tendency to rhythm in behavior, which is of interest to us. We note that the individual apparently distinguishes between the "two-fingers-in-the-fist" movement and the "three-fingers-in-the-fist" movement, since he behaves differently after the one from the way in which he behaves following the other. Simply put, "two fingers" lead to a temporary inhibition of movement, while "three fingers" definitely lead to a variety of uncoordinated movements.

To some extent, of course, this behavior may be likened to the behavior of a child, who, when alone, carries on a conversation, signalling to himself, grimacing, making manual movements, chuckling, whimpering, and otherwise showing the possibility of responding to intraorganic stimuli. But the child's gestures are understandable. They are patterns which gain their meaning from the artificial situation he has created for himself and the conventional references of his responses. The gestures here illustrated, however, can not be explained in terms of an existing situation or by reference to conventional patterns.

Now these gestures are not merely of the self-directed, egotic, as against the ego-alter, type of behavior. They are not implicit responses, evidently, since they do take place overtly, yet they are not the kind of explicit responses that result from extra-organic stimulation. What we are evidently dealing with here is a type of behavior whose chief characteristic is explicit response on the basis of an internal stimulus pattern. If there is meaning in this behavior, it is because the individual alternately carries on a conversation with himself and with a conversationalist. Eugene O'Neill's attempt to present, in his *Strange Interlude,* individuals who converse alternately with others and with themselves is an important psychological venture; except that it disregards the obvious fact that

much of what we "say" to ourselves (much of our internal life) is not vocal, or even verbal, but somesthetic or muscular In other words, much of our self-directed behavior is neither verbal nor verbalizable. The gestures here under discussion prove the importance of O'Neill's oversight.

When the chief object of our behavior is communication with ourselves, we may be said to behave *autistically* Bleuler (3), who originated the term "autistic thinking," speaks of it as a form of thinking in which the individual's attention is temporarily withdrawn from the external situation, thus making it necessary for the individual to express himself more in terms of internal stimulation When an individual, inhibiting his direct response to an external situation, responds to subsequent internal stimulation *explicitly*, we have what we may call *autistic gestures*. Thus defined, they differ not only from the reflex movements of the infant and the well-established conventional responses, but even, in certain respects, from the responses of the child or the adult talking to himself. None of these is characterized by the sequence (*a*) extraorganic stimulation (*b*) inhibited overt response to extraorganic situation (*c*) intraorganic stimulation and, finally, (*d*) explicit response that is not *evidently* directed to the extraorganic situation from which the original stimulation had been derived.

These gestures, which we have termed *autistic* (or self-directed), differ from all other types of expressive movement—from prenatal movements, from infantile gestures, from abnormal tics and postures of neurotics and psychotics (11) This is not to say that autistic gestures differ from all these qualitatively, for they do have certain features in common with all other types of gestures and, indeed, with all types of movement. It might be an aid to clarity, however, if we were to build up a differential scheme in which the autistic-gesture group could be at once compared to and distinguished from all other types of gestures

Such a schema may be constructed with the aid of four major headings, viz., non-social movements, conventional gestures, pseudo-conventional gestures, and autistic gestures These in turn are classified, for comparative purposes, with reference to the following subdivisions, viz, mode of conditioning, conscious or non-conscious behavior pattern, meaningfulness or meaninglessness to subject (or actor), meaningfulness or meaninglessness to observer, similarity or

TABLE 1

Non-social	Conventional	Pseudo-conventional	Autistic
(Prenatal, congenital, animal, infantile, and acultural movements)	(Gesture languages, symbolic codes, customary and institutional forms)	(Artistic, affected, and other socially directed movements)	(Occasional, self-directed symbolic movements, occurring in social situations)
1. Learned prenatally or acquired through maturation	1. Learned on post-natal level, in gradual social contact	1. Learned in special social situations	1. Acquired in personal conflict situations
2 Non-conscious to subject	2 Conscious or semiconscious to subject.	2 Vividly conscious to subject	2 Non-conscious, repressed, so far as subject is concerned
3 Meaningless to subject	3 Directly or symbolically meaningful to subject.	3 Directly or symbolically meaningful to subject	3 Meaningless to subject.
4 More or less understood by observer	4 Generally understood by observer in similar cultural setting.	4 Supposedly understood by observer in similar cultural setting	4. Generally impossible to explain by observer
5 Similar to those of other subjects of the same species.	5. Similar to those of other subjects of the same cultural setting	5 Similar to those of certain special types in a given cultural setting.	5 Unlike those of others in the same cultural setting, and of the same subject under varying conditions *
6 Differentiated from total organismic pattern in normal course of development, but reintegrated into total pattern	6. Specialized forms of adjustment developed in the course of growth of body politic, but relative to entire social structure	6 Specialized pseudo-conventional and pseudo-characterial behavior forms, at least temporarily integrated into a total personality structure	6. Vestigial adjustment patterns unassimilable to total personality
7 Originate in the process of individuation demanded by more complex growth conditions	7. Originate in process of social conflict and accommodation to a more intensive cultural existence	7 Originate in the process of vicarious adjustment to difficult personal problems in social life	7. Originate in frustrated adjustments to personal conflict situations

*It may be that there is only a quantitative distinction between autistic gestures, the tics of neurotics, and the stereotypies of psychotics This point, *at any rate, seems to suggest an important differentiating* characteristic, qualitative in nature, for tics and stereotyped movements appear to be similar under different conditions

dissimilarity in comparison to patterns of other subjects; relation to total pattern from which they had become differentiated, and theory of origin. Such a classification, at once comparing and differentiating autistic gestures, states the problem psychologically, and unifies the threads of our analysis up to this point.

VIII. The Fundamental Nature of Autistic Gestures

When it responds at all, the human organism, like all living organisms, responds as a whole. By saying this we mean that, normally, the organism's responses involve at once the skeletal, the visceral, and (because speech is fundamental to human life), the laryngeal muscle systems A given organismic adjustment, however, may be *dominated* at a given time by the skeletal (motor), visceral (organic), or laryngeal (implicitly or explicitly verbal) system of the organism Total organismic patterns may break up into individuated patterns for purposes of more adequate adjustment; but the break-up, or differentiation, is merely relative and not absolute. The organism retains its capacity for total response, even if, at a given time, its responses may be organized on the motor, organic, or verbal level primarily. When acting on one of these levels, the organism is not disintegrated (as it may become in pathological *cases where the domination of one level of adjustment becomes* permanent), but merely integrated in a special way.

The gestures here under discussion are instances of organismic integration wherein certain cues may arouse organic changes or *motor action which, only with certain refined procedures, can be*come defined in verbal terms. To say this is to dispose of futile questions as to whether gestures may be "purely physical" as well as "mental." The organism acts as a unit, and not alternately as a physical or mental entity. Furthermore, it acts as a unit continuously, i e, even when it is dominated (normally) by one of its reaction systems. Thus there can be no activity which might properly be called irrelevant. All behavior is a function, first, of the organismic integration of the moment, and, second, of the situational stimuli involved

As previously stated, we have labeled responses with which we are now concerned *autistic*, because they do not seem to have direct reference to extraorganic situations. Their nature, however, can

not be explained by the operation of physical as against mental forces but on the assumption that there is a shifting of the organismic integration from the verbal to the motor or visceral levels This shifting always presupposes *inhibition of verbal components* in the response and the consequent existence of what is known as the "abstracted state."

The findings in studies which we have made recently indicate that autistic gestures are non-conscious responses (that is, responses in which there is no *total* organismic integration) which are ordinarily modified by an attempt at verbal definition (12). When a total integration is present, as in conscious inhibition, autistic gestures are reduced to a minimum, and thus either become diffused and scarcely recognizable, or else lead to surrogate responses, such as verbal behavior, conventional gestures, frozen gestures (postures), or another type of autistic gesture replacing those inhibited by cortical interference An illustration of this replacement was obtained from one of our subjects who reported that he had responded to the stimuli verbally (critically) before responding to them gesturally, and that his gestures therefore seemed to follow previous implicit responses to external stimuli The difficulty here evidently explains the lack of success on the part of some subjects in certain of our preliminary experiments By inhibiting consciously the responses to the stimuli, they obtained *secondary* (or indirect) responses in place of the *primary* gestural responses that might have appeared.

Our experimental mass studies, intensive individual studies, and hypnotic-trance studies have shown that autistic gestures are relatively consistent behavior phenomena (12). But in speaking of consistency we must remember that, in the case of these gestures at any rate, we mean similarity of *primary* (or direct) gestures appearing in the *abstracted state.* The reason for this consistency needs explaining. One explanation obviously lies in the consistency of organ or organ-system involved The latter is evidently also an index of the nature of repression and one of the cues that we have to gesture interpretation How do certain organs become associated with certain types of symbolic movement? The answer could be given either in negative terms, i.e., in terms of factors which prevent too wide a spread of gestural expression, or in positive terms, i e., in terms of the conditioning of certain types of organ systems. We shall answer the question in terms which are largely positive

We know that, in a conversion phenomenon, such as paralysis, a low-tension area (arm or leg) becomes stabilized through some drastic inhibition induced by a conflict situation The reason that a certain organ becomes a low-tension area is that it happens to fit into a behavior system which offers release through the channel of that organ or organ system. Since the behavior system becomes conditioned together with the organ system on which it depends, it is clear that the process of conditioning contains the explanation which we are seeking. Occupational employments offer suitable *material for illustration. The organs involved in the person's* occupation may also be involved in the conflicts of the individual, and since the movements, expressive of certain types of vocational adjustment, represent patterns which had become rigidly conditioned in the individual concerned, we find even autistic gestures following these pre-established routes Hence, a carpenter or tailor may be expected to gesture most usually with the hands, while a flutist or saxophonist may be expected to use facial or oral gestures most frequently.

It would seem that there are other than occupational factors on which gesture patterns may be said to be contingent The basic *limitations imposed by what we may term structural (anatomical)* conveniences, that is the greater suitability of one set of organs, rather than of another, to a particular type of symbolic message, can hardly be overlooked. If kicking the leg, for example, represents rejection in a given case, the leg is surely a more convenient means to the end, *because of conditionings associated with leg action,* than smacking the lips would be

However, the habit patterns of the individual are more influential than are mere structural conveniences. This is evident not only from our final statement in the paragraph preceding, but even more from the fact that some exceedingly uncommon, and even inconvenient, postures and gestures are sometimes manifested by individuals seeking symbolic expression Hence, it would appear that conditioned patterns, whether anatomically reasonable or anatomically unreasonable, may be employed for the relief, if only in symbolic form, of an existing organismic tension.

If the involvement of certain organ systems in given types of gestural behavior can be explained through the conditioned patterns of the individual, gesture interpretation ought not to be the *difficult*

matter that it is The reason that merely knowing the major habit patterns of the individual does not yet give us what is needed for the interpretation of gestural behavior is that a knowledge of the habit pattern of the individual merely explains why he tends to resort to one, rather than another, general type of organ gesturing Autistic gestures, as we have previously shown, originate in the *conflict* of habit patterns to which we must turn in order to achieve interpretation. Merely knowing that conflicts lurk back of the gestures is insufficient, however, for competent interpretation of a given instance of gesturing We must have a situational cue temporally connected with the gesture, as well as a *primary* gesture which appeared in the abstracted state, before we can begin to seek interpretation

IX. Summary

1 A gesture is defined as a sharp and quick change from a given postural set or reduced-velocity state, producing a change in the spatial adjustment of the organism

2 In the embryonic organism there is found a differentiation of new movement patterns from total organismic patterns, in which the new behavior units normally retain their relationship to the total patterns and continue under their dominance These differentiated patterns carry over into the post-natal stage in the form of "random movements"

3. Certain early post-natal reflexes not integrated into the total movement patterns of the infant may be regarded as vestigial adjustments continuous with the prenatal movement patterns. These reflexes constitute the basis of the conventional and autistic gestures of later life.

4. The gestures of a feral man confirm the hypothesis that differentiation of movement patterns is relative to total patterns in any given stage, but many continue as vestigial remains, even in the later post-natal stage, *without reference to the total integration at that time*

5 Conventional gestures are differentiated movement patterns which are socially conditioned together with verbal equivalents giving them a certain arbitrary expediency as adjustment mechanisms They are directly perceived, and their sequels are clearly foreseen by both actor and observer

6 Pseudo-conventional gestures, so named, are a form of conditioned behavior employed for non-verbal communication of standard meanings in artificially created situations. They are therefore a species of conventional gesturing.

7 Autistic gestures, so named, are vestigial responses which are seemingly irrelevant to the situations in which they occur, evidently directed to the actor himself (hence, autistic), and not verbally defined either by actor or observer

8. Autistic gestures are easily modified by attempts at verbal definition, and thus can be observed most typically in the "abstracted state," in which verbal components are inhibited

9. Structural (anatomical) "conveniences," the habit patterns of the individual, and situational cues determine the specific type of movement pattern which a given gesture represents

10 The ultimate source of gestural meaning lies in the *conflict* of habit patterns and the response to a pre-existing situation which became inhibited in the resolution of the conflict

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UNE ANALYSE DIFFÉRENTIELLE DU CHAMP DES GESTES

(Résumé)

On peut définir les gestes comme des changements brusques et rapides dans l'adaptation spatiale d'un organisme Les gestes ici considérés sont pris dans le champ du comportement prenatal, du comportement d'un homme sauvage, du comportement pseudo-conventionnel des acteurs, des orateurs publics, des danseurs, etc, et enfin, dans ce champ negligé des mouvements symboliques ici nommés *gestes autistiques* On decrit ceux-ci comme réponses non-conscientes, n'ayant aucune relation, paraît-il, avec la situation où ils se trouvent, et évidemment diriges à l'individu lui-même (donc, *autistiques*) *On ne peut faire aucune ligne de démarcation bien définie* entre les gestes autistiques et les autres types de gestes, car tous les gestes ont de certaines similarités en commun. Il y a d'ailleurs de certains facteurs differentiels, qui placent les gestes autistiques dans une classe speciale Ces gestes, comme montre par quelques-unes des expériences de l'auteur, trouvent leur origine dans les conflits des formes des habitudes Pour les interpreter, cependant, il n'est pas suffisant seulement de savoir que des conflits se trouvent avant ces gestes. Il faut avoir un repère de situation, lié temporellement au geste, avant de commencer à chercher l'interpretation

Krout

EINE DIFFERENTIALANALYSE DES GEBIETES DER GESTEN
(Referat)

Die Gesten durften als scharfe, schnelle Veranderungen in der raumlichen Anpassung des Organismus definiert werden. Die hier betrachteten Gesten werden aus dem Gebiet des Verhaltens vor der Geburt, des Verhaltens eines wilden Mannes, des konventionellen Verhaltens normaler Menschen, des pseudokonventionellen Verhaltens von Schauspielern, offentlichen Rednern, Tanzern, usw., und schliesslich aus jenem vernachlassigten Gebiet der symbolischen Bewegungen, die hier als *autistiche Gesten* bezeichnet werden, ausgelesen. Die letzteren werden als nichtbewusste Reaktionen beschrieben, die scheinbar belanglos für die Situation sind, in der sie vorkommen, und die scheinbar gegen das Individuum selbst (daher autistisch) gerichtet werden. Keine scharfe Linie der Abgrenzung zwischen autistischen und anderen Arten von Gesten kann gezogen werden, denn alle Gesten haben gewisse Ahnlichkeiten gemeinsam. Es gibt aber gewisse Differentialfaktoren, die die autistischen Gesten in eine besondere Klasse stellen. Diese Gesten, wie einige der Experiment des Autors gezeigt haben, nehmen ihren Ursprung in den Konflikten der Gewohnheitsgebilde. Das blosse Wissen, dass die Konflikte diesen Gesten vorangingen, ist aber unbedeutsam fur ihre Deutung. Wir mussen einen Situationsfingerzeig haben, der mit der Gebarde zeitlich verbunden ist, ehe wir anfangen, nach der Deutung zu suchen.

KROUT

INSTRUMENTAL REPRODUCTION OF MELODY BY PRESCHOOL CHILDREN*

From the Department of Psychology, University of Michigan

MARTHA GUERNSEY COLBY

The original purpose of this study was to determine the extent to which pitch discrimination of diatonic intervals could be co-ordinated with simple motor habits in melodic reproduction by young children. The nature of the early results, however, rapidly turned it into a more general experiment in musical training. Though they offer too few quantitative data for detailed statistical treatment, the results are presented for their value in suggesting a number of future experimental possibilities. They likewise provide an interesting comparison to the numerous studies on vocal performance in the young child. Genetic studies of music among children are almost exclusively restricted to this latter medium. Thus the results of Werner (16), Brehmer (1), Nestele (11), Hissem (6), Jersild (8), and others, are based on vocal production or vocal reproduction of tones or melodies. Rupp (15) and Révész (13) used both voice and instruments, but their subjects were in general older than the preschool age. There is no question, of course, that vocal performance appears very early as a potential step in musical behavior. Indeed, if the Spencer theory of the origin of music from speech be accepted, then any of the early vocalizing patterns must be regarded as germinal melodies. There is, however, definite evidence that speech as a utility is very early separated from the child's concept of music. In this experiment, as in Brehmer's, the average child usually went to the extreme of excluding singing proper from his idea of music. The song was "music" if played on an instrument either separately or in accompaniment; without the instrument, it was not "music," but merely "singing"! That singing may be the most natural and effective way of approaching musical training is probably not to be questioned. The primitive "circular response" nature of the aural-oral relationship, both structurally and func-

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tionally, seems well agreed upon. Rhythm, likewise, both spontaneous and imitative, occurs very early, as demonstrated by the author's experiments with percussion instruments (2). The present study is the first of a systematic series to investigate the less known domain of *auditory-manual* coordination From a psychological viewpoint, it undertakes to relate the known manual (digital) capacities, the known imitative tendencies, and the aural perception span of the preschool child to musical action. It has to do not merely with "listening" or "receptive" responses, nor with discrete "tests" of isolated sensory capacities, but rather with the perception, retention, and execution of music's most elementary unit, melodic pattern The simplest melody is, however, far from a simple "gestalt." Its perception presupposes the more basic factors of pitch discrimination, direction, and "distance" or interval between successive units If it is a truly musical pattern, rather than a chance succession of tones, it is at once likely to involve all the complications of harmonic relationship or "tonality," although whether such feeling is established in so young a child is not yet known That such dynamic factors as motivation, emotion, maturation level, etc., are also included is quite obvious. The experimental situation, therefore, except for its extreme *musical simplicity,* seems analogous to the situations in later training, which despite all substitute efforts remain the one infallible test of musical talent

The first part of the work was done in a private nursery school run on standard Merrill Palmer daily routine. A professional instructor in wind instruments acted as experimental assistant. The subjects were 16 children, eight of each sex, between 3½ and 4½ years of age They were selected on the basis of close chronological age, and close "mental" age as indicated by the Gesell and Stutsman norms. Their high social status was relatively homogeneous, the parents representing almost entirely the learned professions On the other hand, the musical background varied considerably from two homes with little or no musical atmosphere to those in which one or both parents were highly trained as performers

The instrument used in the experiment was the common tin fife, retailing at 75 cents, and consisting of six holes which by manipulation produce the complete scale of C-major through several octaves in not too poor a tonal quality. It was selected for several reasons its small size and ease in handling, its inexpensive nature for class

supply, the relative simplicity of its tone, the simplicity (and to *most children the novelty) of its technique* We desired especially to avoid the mechanically determined pitches of the keyboard instruments With the fife, it is possible to get several different tones with the same fingering or combinations of fingering, by simply changing the force of blowing—a concept fairly easy for the small child to grasp. The manual technique requires that the fingers be placed securely and tightly over the holes to maintain any given pitch This likewise is well within the motor ability of the three-year-old as daily shown in play records and various developmental "tests" Whether or not the child would or could coordinate them under auditory control and musical motivation was another question.

The original procedure was to determine how much progress could be made in one semester (4½ months) with two daily class drills of 15 minutes each, with group instruction Needless to say the length of the drill was forced to vary somewhat according to the daily changes in interest, motivation, and attention As the interest *of one or more individuals lagged, they were allowed to turn directly to other activities* If the attention as a whole lagged too much, the lesson was discontinued and the experimenters played simple folk tunes (other than the experimental patterns) as a stimulus toward the next occasion. After six weeks the great differences in individual stages of development made it necessary to divide the class into an advanced and a less advanced group Eventually it was necessary to discard group instruction altogether for individual lessons The experimental procedure may be classified into the following general divisions.

1 Introduction to the instrument The first three periods were devoted to demonstrations by the experimenters (old English, Gallic, and German folk-songs), to very elementary "explanations" of the principles, and to free manipulation by the children. The school staff cooperated by devoting a *daily period to such stories as Pied Piper, The Magic Flute,* etc A very marked degree of interest was thus generated in the beginning as a motive for subsequent "disciplines"

2. The second step gradually introduced "blowing" drills for the mechanics of posture, breathing, fingering Ordinary presentation of the problem was of course hopeless, and before proceeding very far, a definite and permanent terminology based on an elemen-

tary perceptual and linguistic level had to be selected Of all the various systems tried, one was effective: "Open tone, with no fingers," closed tones, with "first finger on the first hole, second finger on the second hole," etc. These had very literal meaning whereas the symbols c, d, e, or even do, re, me, had not.

3. The third step was essentially a series of games in "matching" pitches, with the method clearly explained and visually demonstrated by the experimenters Since a tendency to imitate the motor performance of the adult, regardless of pitch, was quite evident, the children's attention was repeatedly refocused on the importance of the "listening" part Singing or humming the tone, since it occurred so often spontaneously, was encouraged as an incidental aid to ear-training

4. This consisted of three different kinds of pitch discrimination "test," likewise incorporated in games. The visual cues were now lacking, since the experimenters produced each tone from behind a one-way screen. In the *verbal* series, the child was asked whether two successive tones were the same, or different. In the second series, in which the experimenters played "close" simultaneous harmonies, he was asked how many fifes were played. In the third, or *manual* series, he tried to match through his own efforts the pitch played by the experimenter. The intervals used in the first two series were calibrated against adjustable tuning forks as follows

Trial 1 vd 256, 288, 272, 264
Trial 2. vd 288, 320, 304, 296, etc.

The first tone was matched with each of the others successively Due to restricted time, however, the larger differences of ¼ and ½ tone were substituted In the third series, only the diatonic intervals of the *C*-major scale were used as stimuli, since those were the pitches learned in all preliminary motor training. The criterion in this last series was the child's own assurance that he had really "matched" on his own fife the "hide-and-seek" tone behind the screen. His tone was then recorded in musical notation in terms of standard chromatic intervals, or if smaller than these, it was recorded as double-flat, double-sharp, etc. In a more extensive experiment, mechanical recording would, of course, be desirable In this preliminary study, the independent notations of the two experimenters (both conservatory graduates) varied in only four judg-
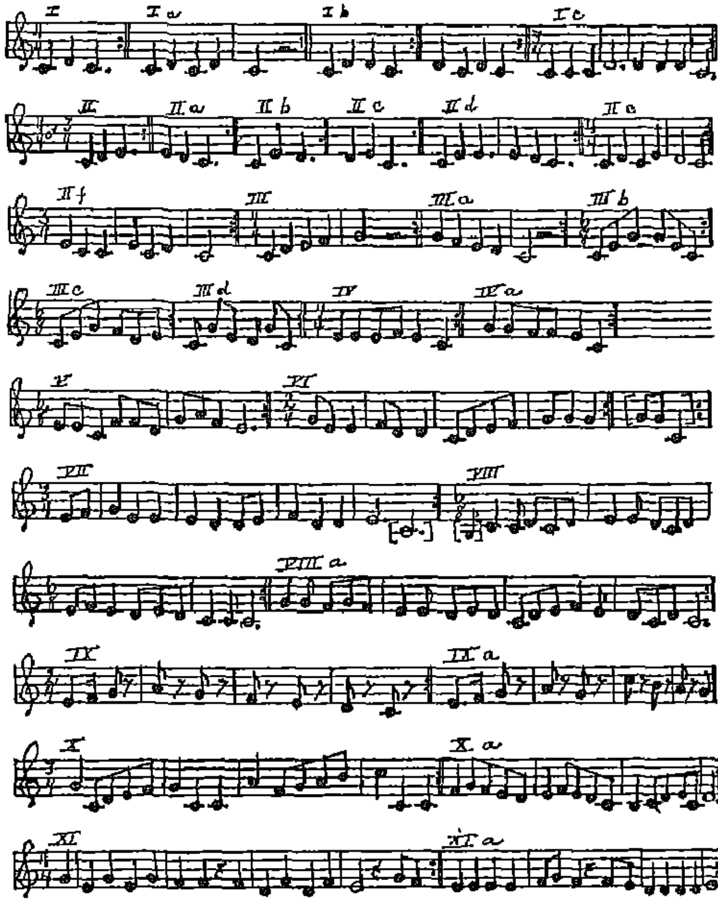
FIGURE 1

MELODIC PATTERNS

No I-II*f*—preliminary or practice patterns.
No III-III*b*—spontaneous vocal melodies (Stern)
No III*c*, III*d*, V—asymmetrical progressions
No IV—vocal Urmotiven (Konig, Stern, Werner)
No VI, VII, XI—folk songs
No VIII, VIII*a*—Mozart's "erstes Liedchen"
No IX, IX*a*—Schumann's "Soldaten Marsch"
No *X*, *Xa*—J S Bach, "Minuet"

ments, all of which involved differences of less than a quarter-tone. In addition to the specific data sheets, descriptive behavior protocols were kept by various trained students in the school, in an effort to get at the "dynamic" phases of musical behavior as well as quantitative learning.

5 The fifth step introduced simple two-unit diatonic "finger-games," viz c-d, c-d, c-d , e-f, e-f, e-f , e-d, e-d, e-d . ...etc, with a great deal of repetition and the gradual introduction of "counting" rhythms in 4/4 and 2/4 time

6. The final step, and the real point of the experiment, was the application of this preliminary training to *melodic* reproduction These data were also recorded in staff notation, double flats and sharps again seeming sufficient to indicate intervals smaller than half-steps. The end criterion, however, as summarized in Table 1,

TABLE I

Subjects 1-12.	
Total number of ensemble drills	140
Average number of ensemble drills per subject	130
Average number of individual drills per subject	29.
Subjects 13-14 (dropped at end of 9th week):	
Average number of ensemble drills	90
Average number of individual drills	17*
Subjects 15-16 (dropped at end of 6th week).	
Average number of ensemble drills	50
Average number of individual drills.	12*

*These individual lessons to the four least talented children were given on the side during the period of their group participation, since it was hoped that such extra prompting would keep them abreast of the others in ensemble work

was the number and kind of melodies "learned" in the applied musical sense, viz, correct number of units, correct harmonic sequences, correct pitch (within ¼ or at most ½ tone) Tempo and *rhythm were noted down, but not used as melodic criteria. While* this system excluded a vast border area of far and near "variations" it seemed no more rigid than was necessary to compare *learned* skills.

Melodic Patterns

In the course of the experiment, some 25 melodic figures were used as patterns. Aside from the "finger-games" earlier described, and the early three-unit patterns (1-3*d*) all melodies were carefully selected from true *musical* sources, or from such experimental sources

as Stern, König, and Brehmer. (See appended notation.) Chromatics, accidentals, modulations were avoided. Appogiatura, trills, etc., were omitted. With the exception of a few melodies in F-major and G-major containing no sevenths, all those written in other keys were transposed to C-major. As it soon became apparent that those patterns involving intervals beyond the sixth were too difficult for the group as a whole, the number of stimulus patterns was reduced to 12.

Results

Due to the limited number of cases and the qualitative nature of the experiment, statistical correlations seem irrelevant. Table 1 indicates certain gross relationships among the more important items. It is based on data from the procedures described earlier, and here summarized in their essential aspects from the following 16 subjects.

In the first column of Table 2 are listed the 16 subjects in rank order of attainment (number of melodic patterns learned). Column 2 indicates the specific patterns learned by each individual subject.

TABLE 2

Subject	Melodic patterns learned	Pitch test (verbal) Per cent	Pitch test (manual) Per cent	School ratings	Experimenters' ratings
1(A)	Experimental series 1-12, additional - 6	90	80	A—	A+
2	1-3*c*, 4, 5, 6, 7, 8, 9, 11*a*	70	65	A	A
3	1-3*b*, 4, 4*a*, 6, 7, 8, 9	60	55	C	A—
4	1-3*b*, 4, 6, 8, 9, 11*a*	65	50	B	B
5	1-3*b*, 4, 4*a*, 8, 9	60	50	A—	B
6	1-3*b*, 4, 4*a*, 6, 7	55	40	B	B
7	1-3*d*, 4, 4*a*, 6	45	50	C	B—
8	1-3*b*, 4, 5, 6	55	40	B	C
9	1-3*b*, 4, 4*a*, 6	40	35	A—	C+
10	1-3*b*, 4, 4*a*	45	35	C	B—
11	1-3*b*	35	20	B—	C
12	1-3*a*	45	30	C	C
13 dropped	1-2*f*	25	10	C—	D
14 dropped	1-2*c*	30	10	C—	E
15 dropped	1-2*a*	20	5	D	D
16 dropped	1-2*a*	35	2	D	E

Column 3 represents the percentage of correct answers in the verbal pitch-discrimination test (with differences of ¼ and ½ tones only), column 4 the percentage of correct responses in the *manual* test. Column 5 is probably fortuitous, since it represents the judgments of the nursery school staff as to the musical behavior of the children prior to the experimental period. No one on the regular staff had more than a very elementary training in music. Column 6 represents the efforts of the experimenters to evaluate "dynamic" factors in behavior such as "interest," volition, enjoyment, etc., during the entire course of the experiment.

Conclusions

Pitch Discrimination. As stated in the beginning, the experiment proved too complex for reliable data on the sense of pitch. Indeed, to isolate this factor per se among young children, it would seem that only as objective a technique as the conditioned reflex is really adequate. The chart does show, at least in its extremes, some evidence of a positive relation between the pitch "tests" and the musical performance. The manual test shows the more consistent correlation, although its difficulty makes the actual figures lower. Data from the second test are omitted from the chart, because the auditory effects of simultaneous tones seem hardly comparable with those of successive single tones. It is of passing interest perhaps that "close" harmonies with pronounced beats were rarely called "one," but rather several "notes," whereas octaves, fifths, and fourths were frequently confused with unisons. If reliable at all, such answers afford genetic confirmation of the perceptual simplicity of these same intervals among adults (3).

Relation of Melodic Pattern to Learning. In general, four components in a melodic figure seem largely to determine the child's success in learning it. These are (1) number of pitch units, (2) the size of the intervals, (3) the direction of the pitch changes, (4) the degree of symmetry. The first factor seems amply illustrated by the abrupt drop in learning with patterns 1*c* and 2*d*, which introduce more than four units, although the interval range continues within a major third. The normal auditory digit span, as determined by Terman's revised Binet tests, is three units at the third-year level and four units at the fourth-year level, five units at seven years, etc. While it might be tempting to correlate our data with these criteria

and attribute the sudden learning plateau with these patterns to the child's limited acoustic span, the *vocal* reproduction of melodies does not bear out its validity Furthermore, the results from our more talented subjects show definitely that melodic memory is not identical with acoustic span In some instances a melodic figure of 10 units was correctly reproduced on the fife at the first or second trial

Certain *general* tendencies, perhaps of a fundamental type, seem similar to those found in vocal reproduction by young children. These concern the other three factors previously mentioned, namely, direction, interval size, and symmetry Ascending intervals are easier than descending ones and diatonic progression seems to be very much simpler than larger skips. No chromatic patterns were used as stimuli in this experiment. The first phrase in the Mozart song (Ex 8) was learned more quickly than the second, even when their order was experimentally reversed In the simpler pattern of 3*b*, the ascending triad was correctly learned in much less time than the descending triad, even when reversed in order This may possibly indicate some feeling of "tonality," with the lower tonic as its fundamental base However, if the triad pattern were "reduced" to an ascending and descending third, as in 2 and 2*a*, no such marked difference in direction error was apparent. Again, if the fifth were reached diatonically (Examples 3, 3*a*) instead of by greater jumps, the accuracy of its pitch was greater than in example 3*b*, and very much greater than when it began a melody (Ex. 8*a*, 10, 11). While these results may well be attributed to the manual difficulties of the instrument, some of them are closely similar to those observed by Brehmer, Ortmann (12), Révész and others in the vocal reproductions of children. Ortmann found that the frequency of error varies directly with the pitch distance of a given interval. In his opinion, all training should be from smaller steps to larger Révész states that some intervals such as the major seventh are very hard even for mature subjects to reproduce In the present experiment, the descending fifths and octaves in the Bach Menuet (Ex 10) and the ascending fourths in Ex 12 (Schumann's Jagerliedschen) proved quite beyond the ability of all subjects excepting one, Subject A And even in *A*'s reproductions the intervals were often diminished either by flatting the *G*, or sharping the *C*, or sometimes both.

The importance of symmetry as an aid to learning seems well illustrated in examples 3*b*, 3*c*, and 3*d* The first pattern was learned correctly by seven subjects, the second by only three, and the last

by only one. The poor "musical" structure of these melodies, in isolated repetition, may account for some of the difficulty in learning them In Ex. 5, however, the second measure took twice as many repetitions as the first measure, although the intervals themselves are not more difficult

A glance at column 2, in Table 2, will show at once the relative difficulty of the various patterns Based on (1) the number of subjects who failed to learn them, (2) the total number of periods required for learning, the general order of decreasing difficulty is as follows.

Ex. 10, Bach Menuet, first phrase
Ex 12
Ex 10*a*, Bach, second phrase
Ex 11, Cuckoo song, first phrase
Ex. 3*d*, and 3*c*
Ex 8*a*, Mozart song, second phrase
Ex 5

These melodies apparently belong, so to speak, in one order of magnitude—the hardest. In terms of learning there is a rather sharp distinction between them and the next, or intermediate group. This second group includes all the remaining patterns except those of Series 1 which, structurally, and functionally, are far the easiest Regardless of which factor or factors may complicate a melody, it seems evident that the difficulty in perceiving, remembering, and executing it is directly proportional to its *total complexity of design.*

Changes in the Original Melody through Reproduction. Space does not permit detailed analysis of the numerous variations on a given figure During the learning period, these had most of the marks of mechanical trial and error. In several cases, however, the final learned act itself was a variation, constant in repeated reproduction, and obviously regarded by the child as a satisfactory duplicate of the original. Thus Example 4 (a primitive "Urmotiv" noted by Konig and Stern) was changed by four subjects to read e-e-*f*-f-e-*e*. (The italicized notes represent the changes). In Example 3*b*, the descending triad often became *e*-e-c instead of g-e-c In Example 7, the progression e-f-g-e-e-e-d often became e-f-g-*g*-*g*-e-d, etc

Taking some 65 variations as a whole, it is again possible to observe certain *general* tendencies common to all the children. These are (1) *simplification* of the melodic contour, by eliminating or re-

ducing the larger intervals and omitting certain units or even certain measures, and (2) perseveration of familiar patterns while learning a new one Both tendencies are less pronounced in the more successful subjects, although they are not lacking completely in any case. It seems logical to assume in explanation that the ability to discriminate its parts within a given pattern would develop earlier among gifted children and lag in the opposite group A further example of reduction or simplifying occurs in Example 5, which was changed in over 50 per cent of the first trials to e-e-*e*-f-f-*f*-g-*g*-*g*-e. The same tendency occurred almost invariably in the Mozart song, in which the third measure was entirely replaced by a repetition of the second measure

Spontaneous Melodies. Some 30 examples were recorded of "spontaneous" sounds made by the children during free manipulation of the instrument Half of these notations represent the early "premelodic" period of learning. The other half are samples from the "free" preliminary periods of five minutes which preceded the later individual lessons Within the first group, it is not possible to find any evidence of a "basic" or even a "common" melodic preference. Nor is there any evidence for beginning pitch preferences. The recorded data show little pattern beyond accidental "toots," single and collective, in the sense of finger manipulation If the ear guided the hand, it is certainly not apparent in the melody. The same conclusions hold largely for the later samples, except that typically the child now substituted one or more of his *learned* melodies for the trial-and-error sounds. A pattern structure is now present, but it is a *learned* structure, not an original invention. Subject A alone seemed predisposed to repeat certain figures he produced by himself—but these were usually detectable *combinations* of the old rather than anything clearly new. It might be expected that if various "Urmotiven" were included among the other melodies to be learned, some natural preference in *reproducing* them would show up. Within the scope of this experiment, such was certainly not the case. Thus Example IV and IV*a*, while moderately easy to learn, never once appeared spontaneously in any of the "free" periods. Example VI (Hannschen Klein) was the popular favorite of those who could even approximate playing it, with the simple patterns of Series II a close second This does not invalidate the concept of the vocal Urmotiv, but on the contrary implies that much of its "fundamentality" in children's singing derives from its par-

ticular type of muscular ease, rather than from any perceptual selection, musically The same negative results occurred with reference to the minor 3rd, which Werner (17) found so frequently in the vocal melodies of young children. If played at all, the 3rd was decidedly major, or even increased, as compared with 4ths, 5ths, and 6ths which were typically reduced

Validity of the Experiment as a Test of Musical Ability When one recalls that Bach, Mozart, and several others at the age of four not only wrote complicated melodies, but harmonized them and performed them, it does not seem so absurd to look for talent, albeit on a lesser scale, among young children. The relative futility of mosaic "tests" *at this early level seems apparent in the pitch discrimination data* Pitch as pitch has little meaning for the child, unless it is incorporated within a fractional whole based on his perceptual level Our data, as well as those of Brehmer, disagree with the statements of Hissem (6) that music should be split into its simplest elements for the preschool child, although not with her experiment which actually did quite otherwise. Not only did she present as stimuli a series of very rich pitch complexes (gong-clang) but accompanied them with both a definite rhythmical pattern and a verbal meaning (words) As a matter of fact, her approach is similar to ours, in that it presents a "reduced whole," but not a "dissected" musical unit. Ours is dissimilar, however, in emphasizing *melody* (pitch changes) as the learning form While all authorities do not agree with Mozart that "Melodie is das Wesen der Musik," most of them do agree that in "melodic sensitivity" the real *musical nature of the average person is shown as by no other method* According to Lipps (9), Révész, Huber (7), and others the talented person perceives and reproduces very different and very complicated melodies; the untalented, only those of few units and simple structure. These authors refer, of course, to *vocal* reproduction But since the instrumental method seems to differ chiefly in its greatly restricted output, this experiment could perhaps be regarded as merely a more severe test than a vocal one, were it not for the rapidly changing motor capacities of the preschool age, which undoubtedly complicate the picture. It is furthermore probable that reproduction on a key-board instrument would be easier than on the fife, since before the latter's tones can be discriminated, they must be produced without benefit of arbitrary control. On the other hand, our subjects seemed to prefer the fife or some other small manipula-

tive instrument—doubtless because these could be "marched with" in imitation of the Varsity Band and the Pied Piper. The analogy between the child and primitive man in this behavior which unifies the sound, the dance, and the drama, has been emphasized by many authorities. This "one-ness" of primitive musical experience would seem, however, to be too rarely considered in teaching music to very young children, although such games as "musical chairs," folk dancing, etc., are worthy exceptions.

Individual Differences. Since these results are qualitative rather than quantitative their significance can best be appreciated by a developmental picture of behavior. From this perspective, the first week's progress is in many ways the most striking. All the subjects quickly tired of "just blowing," i.e., producing an open tone, and most of them soon went their own way in producing accidental tones by manipulating one or more holes with one or more fingers. However, by the end of the third lesson, they could all blow the same open tone, or pitch (C 256), simultaneously, in simple rhythmical units of three-four or four-four time, moderate tempo. By the fifth day, all subjects had mastered the next step of producing a second pitch by covering the first hole with the first finger. By the end of the first week they could imitate in ensemble unison such simple melodic patterns as c, d, c, d, etc. More than these two pitches and four-unit rhythms were still beyond them. This stage of achievement threatened to be the final one for the group and indeed the only progress throughout the rest of the month, in ensemble performance, was the mastery of a third pitch by covering the second hole, and extension of the "finger-games" to d, e, d, e. It is significant that at this stage they could not reproduce thirds correctly, ascending or descending, unless the major 2nd intervened.

By the end of the month, all subjects save No. 15 and No. 16 could reproduce most of the melodic patterns within the restricted compass of the major third. (See variations of Series II.) The experimenters managed to add a little more variety by different rhythmical treatments, most successful, incidentally, when the children could march and blow at the same time. Four subjects never got beyond this stage. Some mastered a few additional patterns, and one child alone attained the desired goal—a repertory of twelve figures.

In order that the experiment might not lose its attraction completely during this plateau interval, the lessons were made shorter

and the experimenters played familiar folk tunes. All behavior protocols excepting those of two individuals showed pronounced kinaesthetic reactions such as jumping, dancing, rolling, humming, which usually began with this music and ceased when it stopped. The great difference between vocal reproduction and manual reproduction was strikingly, if incidentally, brought out by the fact that the children could *sing* more melodies than they could play, at the end of the experimental period It is probably also significant that the children who frequently inhibited the more overt activities to listen closely or watch the performer play were without exception those who reached the highest levels of performance in the experiment In no cases, however, were the kinaesthetic responses completely lacking excepting for the two children who from start to finish showed neither the slightest interest nor proficiency in music (Subjects 15 and 16). The close agreement between columns 2 and 6 is probably to be expected, since the greater enjoyment of the "good" subjects doubtless led to their increased achievement. Révész makes most emphatic this close relationship between musical interest and enjoyment and "musical sensitivity" as a diagnostic clue to talent.

Of the numerous complex reasons making for lack of progress over the next few weeks, some were fairly apparent. One was the physical difficulty of those with very short fingers to cover successfully more than three holes at once With others the span of melodic perception, or the limit of auditory-manual coordination, seemed to have been reached for their particular maturation level. Furthermore, there occurred at this point a complete disintegration of group spirit Some wanted to work faster and longer, some wanted to work less and more slowly The class was accordingly divided into two groups, the first including the five most eager and efficient subjects From the remaining group of 11, subjects 15 and 16 were now dropped, since no amount of individual or concerted effort on the part of the experimenters succeeded in maintaining their interest further. Their nursery school records likewise showed consistent indifference to the "musical period" in the daily program of the school. For a time the change seemed to benefit the other groups They offered alternate "programs" in a visible spirit of competition. The five superior subjects still continued to advance at a faster pace, but even within this small group individual differences soon emerged to destroy the ensemble unity

The sharp difference between the success of the three-unit and the

five- and six-unit melodies, even with the same intervals used, has already been discussed Some awareness of their dilemma at this stage was shown by a few children in such verbalizations as, "This note is the wrong one," "I can't make the right note sound," etc Such remarks seemed to indicate correct perception of the melodic pattern, discriminative recognition of its component pitches, but a lagging motor control in reproducing them. Others were obviously content with their hard-won achievement, and while they seemingly enjoyed the class period, strongly resisted any extension of their individual repertory. During the last two months, the group method of instruction was abandoned, and one individual lesson substituted on alternate days. This change produced another spurt in progress, which, fortunately, lasted well up toward the end

Since subject A was in every respect the most successful product of the experiment, a brief portrait of his behavior may be of interest. Our attention was drawn to him the very first day when he complained that the close harmonies played by the experimenters in the pitch discrimination test "hurt his head." On the fourth day, he said, "I've got a *new* note." To our surprise, he had six fingers tightly down over all the holes and was blowing the most difficult note on the instrument (low D) without its octave. While its production at that time was quite accidental, he was later able to learn quickly the posture, breath control, and finger coordination necessary to reproduce it in a melody. His school ratings in ordinary play and social activity were the lowest of the experimental group, though not of the nursery school group as a whole His records for the daily rhythmic exercises and songs, however, were the highest in the class. His rank in mental norms within the 16 experimental subjects was fifth. (The entire group was selected from the upper quartile of the school.) His age at the end of the experiment was 4 years, 3 months, 17 days, while the mean for the experimental group was 4 years, 3 months, 28 days. His play interests in general tended to be solitary, strongly individual, and somewhat fantastic. Both his teachers and his parents reported that from the first experimental lesson on he talked incessantly about his "music-flute." He was quite unique in really *liking* the "games" of pitch discrimination in which he not only found the right tone, as a rule, but if the consistency in blowing were too different, he would say, "That's it but it's not the same." His greatest errors in reproducing pitches in this way were never greater than a half a tone, and usually well under a quarter tone On several

occasions when he blew too loudly, the octave confused him, and despite explanation, he invariably demanded another fife which didn't "make that other note" A few trials toward the end of the semester in teaching him symbolic notation were ineffectual, although middle C between the two staves was usually properly named. In playing longer melodies he occasionally forgot and stopped, but rarely repeated or omitted. With very little prompting he would finish the tune with evident satisfaction At the end of the semester's experiment he had attained a technique which included all 12 of the experimental patterns, a repertory of six additional tunes such as "Lightly Row," (first phrase) "I Can Play My Violin," "Yankee Doodle," and an assortment of small "original" melodies which he consistently repeated. As stated earlier, however, these were largely composites of the others.

As far as could be determined, the child's parents had only minimally "average" musical interests or capacities, and neither one was a performer The maternal grandfather, however, had led his village band in rural Germany and played the parish organ On so little evidence nothing can be said of hereditary talent in the child's behavior On the other hand, neither can his home environment, far less musical than that of some of the other children, account for his marked superiority in the experiment While it is impossible to predict what his future success will be, since he too may at any given time arrive at a maturation limit, it seems significant thus far that his school grades in music in the kindergarten and his success in a private piano class have remained consistently higher for two years than any other's in the groups Incidentally, while it had never occurred to the parents to give him specialized musical advantages, the outcome of our elementary fife experiment has converted them to the desirability of a musical environment and appropriate training facilities.

In an applied sense, the experiment would seem to indicate that specialized instrumental training at too early an age (preschool) costs far more patience than it is worth, and that the same amount of effort applied to *vocal* acquisition of folk-songs, folk-games, "Kinder lieder," etc., would produce greater results because it would capitalize on a natural response and an easier technique On the other hand, a minimal amount of auditory-manual training under appropriate musical discipline may obviously foster an interest in instrumental music, and thereby deepen its aesthetic value later on

In a scientific sense, the experiment indicates several possibilities for investigating musical development within a "reduced" but nevertheless normal "aesthetic" situation.

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LA REPRODUCTION INSTRUMENTALE DE LA MÉLODIE PAR LES ENFANTS D'ÂGE PRÉSCOLAIRE

(Résumé)

Cette étude essaie d'approcher les capacités musicales des jeunes enfants, non pas au moyen des tests mosaïques, mais en coordonnant les capacités manuelles connues, les tendances imitatives, la portée de la perception, et les niveaux de motivation de l'âge préscolaire dans un acte musical appris, par ex., la reproduction instrumentale des mélodies simples Les matériaux principaux ont été des fifres et des figures soigneusement choisies de chansons populaires, des classiques juvéniles, et les divers motifs employés par d'autres investigateurs On a employé quatorze sujets pendant la durée d'un semestre, avec l'entraînement collectif et individuel Le succès dans l'apprentissage dépend surtout de quatre variables—le nombre des unités de hauteur, la grandeur des intervalles, la "direction" de la mélodie, et le degré de répétition ou de symmétrie La tendance générale à simplifier chacun ou tous ces facteurs est plus marquée chez les sujets les moins capables La motivation adéquate est très difficile pour les moins capables L'activité spontanée ou "libre" avec l'instrument ne montre aucune evidence des "Urmotiven" qui se trouvent dans les premières formes vocales La portée mélodique comme unité perceptive est quelque chose très différent de la simple portée acoustique, ce qui indique l'importance de la forme dans l'expérience vraiment musicale Les différences individuelles varient de l'insuccès complet jusqu'au succès presque parfait dans les séries d'apprentissage

COLBY

DIE INSTRUMENTALWIEDERGABE VON MELODIE VON VORSCHULPFLICHTIGEN KINDERN

(Referat)

In diesem Experiment wird der Versuch gemacht, die musikalischen Fähigkeiten junger Kinder zu untersuchen, nicht durch Mosaiktests, sondern durch das Zusammenbringen von bekannten Handfertigkeiten, Nachahmungsneigungen, Wahrnehmungsumfang, und Motivierungsniveaus des vorschulpflichten Alters in einen gelernten musikalischen Akt, nämlich in die Instrumentalwiedergabe von einfachen Melodien Die Hauptmaterialien waren Pfeifen und sorgfältig ausgewählte Melodien aus Volksliedern, Jugendklassiker, und die verschiedenen Melodien, die von anderen Forschern gebraucht wurden Vierzehn Vpn. dienten für einen Zeitraum von einem Semester und erhielten sowohl Gruppen- als auch Einzelunterricht. Der Erfolg beim Lernen hängt hauptsächlich von vier Variablen ab von der Anzahl der Tonhöheneinheiten, der Grosse der Intervalle, der "Richtung" der Melodie, und dem Grad der Wiederholung oder Symmetrie. Die allgemeine Neigung zur Vereinfachung jedes dieser Faktoren ist bemerkbarer bei den weniger begabten Vpn. Hinreichende Motivierung ist äusserst schwierig bei den am wenigsten begabten Vpn Freiwillige oder "freie" Tätigkeit mit dem Instrument weist keine Evidenz solcher Urmotive auf, die in frühen Stimmgestalten vorkommen Der Melodieumfang als eine Wahrnehmungseinheit ist etwas ganz verschieden von dem einfachen Gehörumfang, was auf die Wichtigkeit der Gestalt in wahrhaftig musikalischer Erfahrung hinweist Individuelle Unterschiede verbreiten sich vom vollkommenen Misserfolg bis zum beinahe vollkommenen Erfolg in der Lernreihenfolge.

COLBY

A STUDY OF SOME OF THE TECHNIQUES UNDERLYING THE ESTABLISHMENT OF SUCCESSFUL SOCIAL CONTACTS AT THE PRESCHOOL LEVEL*[1]

From the Department of Child Study of Vassar College

HELENA MALLAY

One of the aims of nursery school education is to teach children techniques for playing with other children in such a manner that they become in some integral way associated with every other child in the group. The present investigation was undertaken to determine the various types of social behavior patterns occurring at the preschool level and from these to discover the techniques of successful social approach and successful maintenance of contact, i.e., techniques for the initiation and maintenance of *group* contacts.

A *group* contact was here defined as two or more children functionally and spatially together, with some common underlying aim or interest, though not necessarily of the overt type. This interrelationship had potentialities for cooperation within the group both along the road toward and in the attaining of the goal. There was a positive feeling among the members and acceptance of each by the others. Such a group may have had destructive aims as regards the rest of society, yet so long as similar aims and mutual interest and aid in attaining a goal was evident, these members were a group.

Active cooperation among two-year olds was not always manifested overtly yet a common underlying aim and some basis for interrelationship were present. This leads one to question whether group behavior of two-year olds was not merely an immature form of the more highly developed group activity at the four-year level. Individual sand pies mutually admired by two-year olds became part of a bakery with four-year olds.

*Recommended by Dr. Martha May Reynolds, accepted for publication by Carl Murchison of the Editorial Board, and received in the Editorial Office, January 24, 1935.

[1]This study was directed by Martha May Reynolds, Professor of Child Study, Vassar College.

The two major problems established were "What are some of the factors underlying the initiation of successful contacts?" and "What are some of the factors underlying the maintenance of *group* contacts?"

The initial contacts (approaches) were distinguished from the resulting maintained contacts and analysis of the two undertaken separately A further division was made between *successful* approaches and approaches as well as between maintained *group* contacts and maintained contacts Maintained *group* contacts included those social situations in which the children were moved by a common underlying aim into patterns of behavior which kept them functionally and spatially together while maintained contacts were simple social contacts which did not have in them the elements of *group* activity Similarly, successful approaches were those which elicited maintained *group* contacts while approaches called forth simply the maintained contacts which by definition did not contain elements of *group* activity.

Subjects

The subjects were 21 children in attendance at the Vassar College Nursery School during the year 1933-1934. Their chronological ages ranged from 2 years, 0 months to 4 years, 9 months, as of October 15, 1933, the midpoint of the first period of observation. Average chronological ages, mental ages, and intelligence quotients are given in Table 1 for the age groups in year intervals as studied

TABLE 1
CA's, MA's, and IQ's of Age Groups Studied

	Two-year olds	Three-year olds	Four-year olds
No of cases	7	7	7
Av. C A	2-4*	3-7	4-4
Range	2-0 to 2-11	3-3 to 3-11	4-0 to 4-9
S D	±3 62 months	±3 09 months	±2 99 months
Av. M.A	2-8	4-3	5-7
Range	2-4 to 3-0	3-11 to 4-8	5-0 to 6-3
S D	±2 83 months	±3 00 months	±4.73 months
Av IQ	115	121	130
Range	103 to 140	109 to 131	120 to 141
S D	±14 63	±7 48	±6 78

*2-4 signifies 2 years, 4 months.

Name of Child Jackie S

Date and Time 10/9/33-1010

	Social Approaches				Social Receipts				Diary Record
Time	To	Vocal	Mat	Act	From	Vocal	Mat	Act.	
1- 0	N		KK	fights for it					Fights with Nancy for KK
10	N		·	·					pounds her Δ (teacher)
20								removes him	removes him
30	N			touches shoe					Stands by, touches N's shoe,
40	N.		KK	bell					plays with bell on KK N
50	N	all through		bell N					falls over with KK He caresses her
2- 0		Look! Look!	Slide	Slides					Runs off to slide-G&N follow
10		· ·							
20	G,N		·		G,N		Slide	comes to slide	
30	G,N	''							
40	G,N								
50	G,N								
3- 0				across yard					Leaves-goes to shed gets
10			truck	manip					truck-manipulates it-
20				·					finally sits on it
30									
40									
50	Jo	Did you wet		sits on it					
4- 0				walks off					Speaks to Jo-follows Jo
10	Jo Δ	what							& Δ across yard gets 2
20			sand toy	manip					pails from sand toy basket
30									places them in sandbox
40	Jh		·	manip, pushes Jh					pushes Jh away
50				manip					
5- 0	G,N,	over to slide	slide	slides					goes to slide where G&N
10	G,N	sings	·						are-slides with them,
20	G N	go on							Much hilarity and singing
30	G,N	No							Jh comes over Ja watches others slide
40	G,N,Jh	sings		stands by	Jh	Look!	slide	slides	
50	G,N,Jh	boom!	·	watches Δ					

FIGURE 1

OBSERVATION RECORD

Above is a sample record for a five-minute observation of a subject, timed to ten-second intervals. The first third of the sheet included all the items of social behavior of significance to this problem where the initiative was the subject's, i.e., (1) initials of the children reacted to socially through any of the channels of social approach—regard, vocalization, physical contacts through materials, direct physical contact, parallel activity, or cooperative activity—during each of the ten-second intervals of the five minutes. To these initials was added a cross (x) whenever physical contact

through materials occurred and a dash (—) whenever direct physical contact occurred, (2) any vocalization by the subject; (3) the materials in use at the time, (4) the activity in which the subject was engaged The second major division of the sheet provided for corresponding information about any child approaching the subject (where the initiative was not the subject's). His initials were inserted in the correct time interval under the first sub-column and data about vocalization, physical contact through materials, direct physical contact, parallel, or cooperative activity noted This second section was not a continuous record The third major division of the sheet was used for a complete diary record of the activity during the five minutes. A regulation stop watch was used. Notes were taken in a form of shorthand.

A two-hour observation was made of each subject (24 five-minute records), one hour in the Fall and one hour in the Spring Such a plan furnished data for a comparative study of changes in social behavior patterns after six months of nursery school experience.

Notes on Analysis

A method of analysis in terms of patterns rather than of items was adopted. In each approach and in each maintained contact the following items of social behavior activity were involved, either singly or in combination:

visual regard of each other
directed verbal statement or other vocalization
physical contact directly or through materials
parallel activity
cooperative activity

These five appeared so frequently in and were so common to approaches and to maintained contacts that they were assumed to be basic items. Other factors such as hyperactivity of the child's approach, physical bearing of the child, intellectual elements, and emotional tone of the approach were considered individual overtones rather than items in the social behavior pattern. These were omitted in the analysis in an attempt to remove those factors which were personality characteristics rather than basic items of social behavior.

Quantitative data were on hand as to the frequencies of the basic items in approach and in maintenance of contact. But it was not possible at this stage to determine the influence of each item toward the success of the approach, i e., whether the items Regard, Vocalization, or Parallel Activity were equally responsible or one carried greater weight than another. In order to minimize the possible sources of error, it seemed best in the analysis to consider the total pattern, made up of the basic items Regard, Vocalization, and Parallel Activity, responsible for the success of the approach rather than to try to weight the individual items

The following eight pattern types were adopted for use

1 *Regard* looking at another child while standing by inactive or engaged in an unrelated activity

2. *Regard and Vocalization*: verbal statement or laughter, accompanying looking at another child while standing by inactive or engaged in an unrelated activity

3. *Regard and Physical Contact*. physical contact directly or through materials accompanying looking at another child while standing by inactive or engaged in an unrelated activity No vocalization occurs.

4. *Regard and Parallel Activity* looking at another child while engaged in related activity, similar but independent. No vocalization occurs

5 *Regard and Cooperative Activity*· looking at another child while engaged in related activity, interdependent and supplementing each other toward a common goal. No vocalization occurs

6. *Regard, Vocalization, and Physical Contact* physical contact either directly or through materials accompanying looking at another child while standing by inactive or engaged in an unrelated activity. Vocalization does occur.

7. *Regard, Vocalization, and Parallel Activity*· looking at another child while engaged in related activity, similar but independent Vocalization does occur

8. *Regard, Vocalization, and Cooperative Activity*· looking at another child while engaged in related activity, interdependent and supplementing each other toward a common goal Vocalization does occur.

These patterns were considered mutually exclusive Each ap-

proach and each contact was listed under the type most representative of it

Analysis Record

Each item in approach and in maintenance of contact was graphed on a master sheet (one for each subject) in such a way that it appeared at one and the same time separately yet within its pattern In this way, details of the patterns could always be evaluated correctly in the light of the larger total pattern

Purely statistical treatment of the data might show for one child a total of 50 regards and 45 vocalizations present in six maintained contacts. Analysis by patterns might show that five of these maintained contacts were characterized simply by regard while the other *one* carried the total 45 vocalizations. Consideration of the items per se might lead one to conclude that the type of contact used

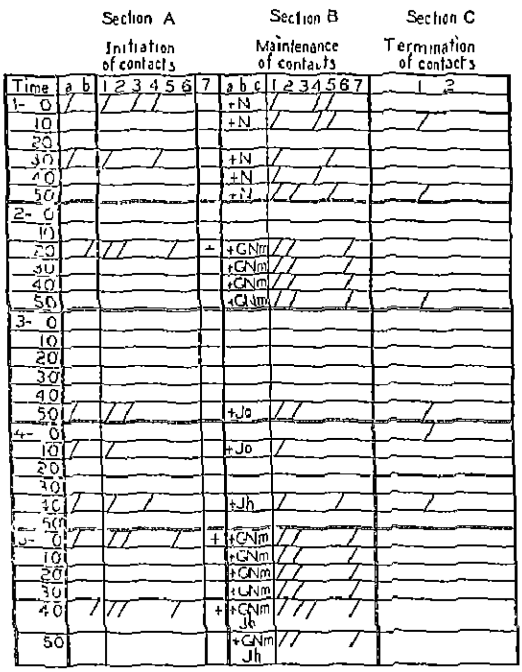

FIGURE 2

most frequently by the subject was a *Regard and Vocalization* type, there being almost as many vocalizations as there were regards. Analysis by patterns showed definitely the predominance of contacts of the type *Regard*.

Below is a sample analysis sheet of the sample observation record given above. Under Section A were charted the data for the study of approaches. A check was made under sub-column *a* and in the correct time interval if the subject on whom the record was taken approached another child; in sub-column *b*, if he was approached by the other child. (For the present study, approaches under *a* and *b* were summed for the total frequency of approaches.) In analyzing the pattern type, checks were made in the columns 1, 2, 3, 4, 5, and 6 (see sample sheet) for the items involved, Regard, Vocalization, Physical Contact directly or through materials, Parallel Activity, and Cooperative Activity respectively. Column 7 was marked with a plus whenever the approach was successful, i.e., resulted in the establishment of a *group* contact and left blank when not successful.

Under Section B were recorded the data for the study of maintained contacts. A plus was written in column *a* for each interval during which a contact was maintained. In column *b* were listed the initials of those children other than the subject in the contact and in column *c* was recorded an "m" for the intervals and for only those intervals during which the subject was a member of a group. Analysis for pattern type was carried out by checking in columns 1, 2, 3, 4, 5, 6, and 7 respectively the occurrence of Regard, Vocalization by the subject, Vocalization by another child, Physical Contact through materials, Direct Physical Contact, Parallel Activity, and Cooperative Activity for each ten-second interval during which any of the seven items were recorded.

Under Section C was noted the breaking up of a contact either by the withdrawal of the subject or by the withdrawal of other members. It was only when the subject left or when *all* the other members left that the contact was considered ended.

DATA

Study of Approaches. From Section A on the master sheet, there was computed for each subject the total number of approaches

occurring during his two-hour observation and the total number successful. These were sorted and listed according to pattern type For example, of the 108 approaches listed for one child, 22 were of the type *Regard;* 31, *Regard and Vocalization;* 8, *Regard and Physical Contact,* 24, *Regard and Parallel Activity,* 2, *Regard and Cooperative Activity;* 4, *Regard, Vocalization, and Physical Contact;* 11, *Regard, Vocalization, and Parallel Activity;* 6, *Regard, Vocalization, and Cooperative Activity.* Similarly, the number of successful approaches per type were found For example, in the case above, of the 22 approaches of the type *Regard,* 1 proved successful in establishing a *group* contact; of the 31 *Regard and Vocalization,* 7, of the 8 *Regard and Physical Contact,* 2, of the 24 *Regard and Parallel Activity,* 15, of the 2 *Regard and Cooperative Activity,* 2; of the 4 *Regard, Vocalization, and Physical Contact,* 0, of the 11 *Regard, Vocalization, and Parallel Activity,* 10; of the 6 *Regard, Vocalization, and Cooperative Activity,* 6. For each subject there were data on (*a*) the frequency of approach, (*b*) the frequency of successful approach, (*c*) the distribution of approaches among the eight types, and (*d*) the percentage of success per type

Study of Maintained Contacts. From Section B, there was computed for each subject the total number of seconds in social contact with other children (there were possible 7200 seconds for social contact—each of the 24 observations having 30 ten-second intervals, totaling 7200 seconds) and the number of seconds in *group* contact. Each of the maintained contacts was listed according to pattern type and the success per type obtained by finding the ratio of the number of maintained *group* contacts to the total number of maintained contacts. For each subject there were data on. (*a*) the total number of seconds in social contact; (*b*) the total number of seconds in *group* contact; (*c*) the frequency distribution of maintained contacts among the various types; and (*d*) the percentage of success per type The average length of a contact and the average number of children in a group were also found.

This study was essentially a study of "approaches" and "maintained contacts" and not, at this point, a study of individual children. Emphasis was placed on the behavior of the child rather than on the child as an individual. For example, when Jane's

Regard was considered, the interest was in the Regard as an item of social behavior rather than in Jane as a personality.

SUMMARY OF DATA GATHERED

In the study of the initiation of contacts (approaches) there were found:

1 Total number of approaches
2 Total number of successful approaches
3 Frequency distribution among eight pattern types
4 Percentage of success per type, i.e., ratio of number successful to total number per type

In the study of the maintenance of contacts there were found:

5 Total number of seconds in social contact
6 Total number of seconds in *group* contact
7. Frequency distribution of separate contacts of varying lengths among eight pattern types
8 Frequency distribution of *group* contacts among eight pattern types, the ratio of (8) to (7) giving the success per type.
9 Average length of a maintained contact
10 Average number of children per group

Results on these points were gathered for the entire group of 21; for the two-, three-, and four-year olds separately. Figures were also obtained for the total two-hour observation period, for the Fall and Spring observation periods

Total data may be graphically presented as follows:

Group Observ	Entire Group			2yr olds			3yr olds			4yr olds		
	2hr	Fall	Sprg	2hr	Fall	Sprg	2hr	Fall	Sprg	2hr	Fall	Sprg
Items 1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

FIGURE 3

TABLE 2

PERCENTAGE OF SUCCESS IN THE INITIATION OF CONTACTS

	Entire group 21			Two-year olds 7			Three-year olds 7			Four-year olds 7		
	Total	Fall	Spring	Total	Fall	Spring	Total	Fall	Spring	Total	Fall	Spring
Total approaches made	1976	1011	965	543	276	267	689	351	338	744	384	360
Total number successful	540	224	316	144	60	84	167	75	92	229	89	140
Percentage of success	27 3	22 2	32 7	26.5	21 7	31 5	24.2	21 4	27 2	30 8	23 2	38 9
Average number of approaches per child	94 09	48 14	45 95	77 57	39 43	38 14	98.43	50 14	48 29	106 29	54 86	51 43
Average number of successful approaches per child	25.71	10 66	15 05	20 57	8 57	12 00	23 85	10 71	13 14	32 71	12 71	20 00

The Initiation of Social Contacts

1. *Quantitative Analysis* Table 2 lists the total number of approaches, the total number successful, and the percentage of success (ratio of number successful to total number made) for the entire group of 21 subjects, and for the separate groups of two-, three-, and four-year olds. The lower section of Table 2 gives the averages per child for the two items—number made and number successful. The questions raised could now be answered: What success did the preschool child achieve in the initiation of social contacts? What were the age level variations? What differences in success were evident from the Fall to Spring periods?

The percentage of success in the initiation of social contacts at the preschool level was 27 3 The separate percentages at the two-, three-, and four-year levels, i e , 26.5, 24 2, and 30 8 respectively, were very close and the difference found to be not statistically significant, suggesting that at the preschool level the development of techniques for the initiation of successful contacts was slow Since the data showed the four-year olds to be not more successful than the two-year olds, the establishment of techniques for successful approach seemed to be not wholly a matter of maturation. Moreover, a significant difference between success attained in the Fall and that reached in the Spring was noticed for the entire group. The question arises What is the relative importance of maturation and learning in the establishment of techniques for successful social behavior?

2 *Qualitative Analysis* The following questions were raised: Which were the pattern types of approach most common at the preschool level? Which were the most successful? What age level variations were evident? What changes were noted from Fall to Spring?

Table 3 lists for each of the eight pattern types its percentage of frequency of occurrence in the total 1976 approaches studied The three most frequently used types were *Regard; Regard and Parallel Activity,* and *Regard and Vocalization,* one or another making up 79 2 per cent of the total number. The remaining five types, occurring 20 8 per cent of the time, showed individual frequencies of 1.4 per cent to 9.1 per cent Although the percentages

TABLE 3

PERCENTAGE DISTRIBUTION OF APPROACHES AMONG VARIOUS TYPES

	Entire group 21			Two-year olds 7			Three-year olds 7			Four-year olds 7		
	Total	Fall	Spring	Total	Fall	Spring	Total	Fall	Spring	Total	Fall	Spring
Types of patterns												
Regard	39.7	42.6	36.7	40.7	48.6	32.6	45.4	44.7	46.2	33.7	36.4	30.9
Regard and Vocalization	19.1	18.3	20.0	9.8	7.2	12.4	18.1	17.9	18.3	26.9	26.6	27.2
Regard and Physical Contact	9.1	10.3	7.8	16.9	16.3	17.6	8.7	11.4	5.9	3.6	4.9	2.2
Regard & Parallel Activity	20.4	17.6	23.3	22.6	18.5	27.0	18.3	16.5	20.1	20.7	17.9	23.6
Regard & Cooper. Activity	1.4	1.3	1.7	0.5	0.7	0.3	1.5	1.1	2.1	2.0	1.8	2.2
Reg., Voc., & Physical Cont.	2.4	2.8	2.0	2.1	1.4	3.0	2.2	2.8	1.5	2.7	3.6	1.7
Reg., Voc., & Parallel Act.	6.1	5.4	6.9	6.3	6.1	6.4	4.7	3.1	5.9	7.4	6.8	8.1
Reg., Voc., & Cooper Act.	1.8	1.8	1.8	0.9	1.1	0.7	1.2	2.3	0.0	2.9	1.8	4.2

TABLE 4

PERCENTAGE OF SUCCESS PER TYPE OF APPROACH

	Entire group 21			Two-year olds 7			Three-year olds 7			Four-year olds 7		
	Total	Fall	Spring	Total	Fall	Spring	Total	Fall	Spring	Total	Fall	Spring
Types of patterns:												
Regard	2.9	2.3	3.7	3.6	2.9	4.6	2.9	1.9	3.8	2.4	2.1	2.7
Regard and Vocalization	16.6	21.6	11.9	9.4	15.0	6.1	18.4	23.8	12.9	17.5	21.6	13.3
Regard and Physical Contact	10.1	11.6	8.0	13.0	20.0	6.4	6.6	7.5	5.0	7.4	0.0	25.0
Regard & Parallel Act	70.0	56.2	80.9	68.3	51.0	80.6	67.2	58.6	76.4	72.7	57.9	84.7
Regard & Cooper Act.	89.7	84.6	93.7	100.0	100.0	100.0	90.9	100.0	85.7	86.6	71.4	100.0
Reg., Voc., & Physical Cont.	10.7	7.1	15.8	16.6	25.0	12.5	6.6	0.0	20.0	10.0	7.1	16.6
Reg., Voc., & Parallel Act.	74.2	59.3	86.4	76.5	76.5	76.4	78.8	72.7	90.0	67.3	42.3	82.9
Reg., Voc., & Cooper Act.	97.1	94.4	100.0	80.0	66.0	100.0	100.0	100.0	0.0	100.0	100.0	100.0

varied slightly, results at the Fall observation and the Spring observation for the entire group and for the separate two-, three-, and four-year age levels all upheld the conclusions drawn above that those three pattern types were used most frequently as techniques of approach. These data are shown graphically below (Figure 1*a*).

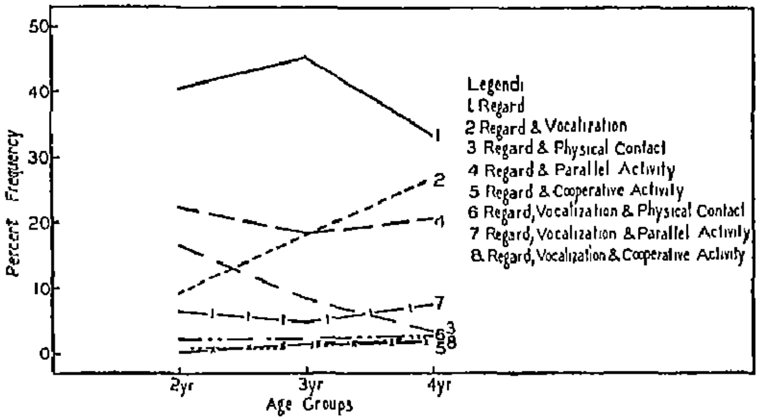

FIGURE 1*a*

Table 4 shows that at all age levels and at both the Fall and Spring observation periods, four of the eight types of approach resulted almost invariably in establishing successful contacts; the other four almost invariably failed to do so. This "all-or-none" characteristic of the results may be seen more clearly in Figure 1*b* on page 444. The pattern type found to be most successful was *Regard, Vocalization, and Cooperative Activity*, 97.1 per cent of such approaches resulting in the establishment of a *group* contact. *Regard and Cooperative Activity* had 89.7 per cent success; *Regard, Vocalization, and Parallel Activity*, 74.2 per cent; *Regard and Parallel Activity*, 70.0 per cent. The most unsuccessful type of approach was *Regard*. Only 2.9 per cent of such approaches resulted in the establishment of a *group* contact; with *Regard and Physical Contact*, 10.1 per cent; *Regard, Vocalization, and Physical Contact*, 10.7 per cent; *Regard and Vocalization*, 16.6 per cent.

The types of approach which proved successful retained their

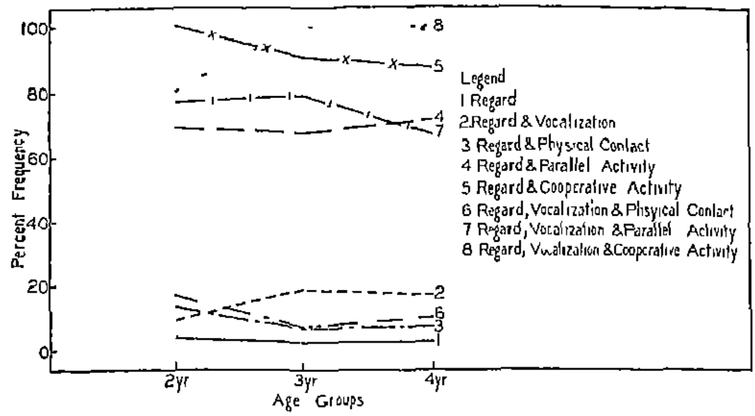

FIGURE 1B

success potentialities with all the subjects, the two- as well as the three- and four-year olds, and at all times, in the Fall or Spring The types proving unsuccessful remained consistently unsuccessful at all times and at all age levels The question arises: Might not the factors underlying the initiation of successful social contacts be fairly independent of the factor of age level and of the factor of existing social relationships between the subjects?

3. *Conclusions* An attempt was made in this section to discover some of the factors underlying the initiation of successful contacts. Results showed that an approach following the general pattern of *Regard, Vocalization, and Cooperative Activity* or *Regard, Vocalization, and Parallel Activity* was fairly certain of success in establishing a *group* contact In so far as *Regard and Cooperative Activity* and *Regard and Parallel Activity* without accompanying vocalization were also types which resulted in the establishment of *group contacts,* might it not be said that the two elements—Cooperative Activity and Parallel Activity—appearing one or the other in most of the successful pattern types were the important factors facilitating the initiation of successful social contacts?

Furthermore, it may be said that these factors of Cooperative or Parallel Activity were fairly independent of the individual personality pattern. They were equally successful when used by the two-, three-, and four-year olds, in the Fall and in the Spring, by

the child who was most maladjusted personally and by the child with the best personality adjustment, by the child with the highest intelligence quotient and by the one with the lowest. Success seemed to be, to a greater extent, a matter of type of approach used rather than of individual personality pattern behind it

The question of the relative importance of maturation and learning by experience in the initiation of successful contacts will be taken up in another section, page 451

Analysis showed that only 27 3 per cent of all the approaches made by two-, three-, and four-year olds resulted in the establishment of *group* contacts Analysis showed further that 70 3 per cent of the approaches made at these age levels were of the four types found above to be almost certain of failure—*Regard, Regard and Vocalization, Regard and Physical Contacts; Regard, Vocalization, and Physical Contacts* Small wonder that success was limited!

The Maintenance of Social Contacts

In the quantitative analysis, individual contacts varying in length from 10 sec. to 300 sec were not kept separately A 10-sec contact, a 30-sec one, a 90-sec, and a 120-sec one were added and the 250 sec. listed as the total contact for that child, with no reference at this point to the fact that four individual contacts of varying lengths were contained therein In the qualitative analysis, each maintained contact was considered separately, the 250 sec above were treated as four individual maintained contacts and the type of each determined

1 *Quantitative Analysis* Table 5 shows the percentage of free play time spent in social contact and the percentage of success in maintaining *group* contacts (time in *group* contact to total time in any kind of social contact) Answers to the following questions were sought What percentage of free play time was spent in any sort of social contact? What percentage of time spent in social contact was *group* contact? What variations in age level were found? What changes were noticed from Fall to Spring?

The preschool child spent 61 per cent of his free play time in social contacts of any sort (ratio of the total number of seconds in social contact to the 7200 sec total observation time per child); the two-year olds, 41 per cent, three-year olds, 64 per cent, four-

TABLE 5
PERCENTAGE OF SUCCESS IN MAINTENANCE OF SOCIAL CONTACTS

	Entire group 21			Two-year olds 7			Three-year olds 7			Four-year olds 7		
	Total	Fall	Spring	Total	Fall	Spring	Total	Fall	Spring	Total	Fall	Spring
Percentage of free play time in Social Contact	61.0	55.5	67.0	41.0	33.0	50.0	64.0	61.0	67.0	77.0	70.0	83.0
Number of seconds in Social Contact	91980	41390	50590	20960	8250	12710	32300	15430	16870	38720	17710	21010
Percentage success in Social Group Contact	56980	22040	34940	11750	3500	8250	18080	8030	10050	27150	10510	16640
Percentage Success in Social Contact	61.9	53.2	69.1	56.0	42.4	64.9	55.9	52.0	59.5	70.1	59.3	79.2
Average number of seconds in Social Contact per child	4380	1971	2409	2995	1179	1816	4614	2204	2410	5531	2530	3001
Average number of seconds in Social Group Contact per child	2714	1050	1664	1679	500	1179	2583	1147	1436	3878	1501	2377

year olds, 77 per cent However, the percentages of success in the maintenance of *group* contacts attained by the two-, three-, and four-year olds were found to be very close—56 0 per cent, 55 9 per cent, and 70 1 per cent respectively. There was no difference between the results for the two- and three-year olds and a statistically insignificant difference between the results for the two- and three-year olds on the one hand and the four-year olds on the other hand (D/σ_{diff} was 2 0).

Significant differences and definite progress at all age levels in the ability to maintain *group* contacts after six months in the nursery school were noted Percentages of success were much higher at all age levels during the Spring than during the Fall. Moreover, the two-year olds in the Spring were more successful than the three- and four-year olds in the Fall and the three-year olds were more successful in the Spring than the fours in the Fall.

Since the success of the four-year olds was not much greater than that of the two- and the three-year olds and the progress shown from Fall to Spring was significant for all the age levels, it seemed that other factors besides maturation were responsible for the maintenance of *group* contacts The question again arose. What is the relative importance of maturation and learning by experience in the maintenance of *group* contacts?

2. *Qualitative Analysis.* In Table 6 is given for each pattern type of maintained contact the percentage of frequency of occurrence among the total 1726 maintained contacts studied The questions raised were: Which were the most frequently occurring pattern types of maintained contacts? Which were the most successful? What age level variations were evident? What changes were noted from Fall to Spring?

The three types of maintained contacts occurring most frequently at all age levels and at both the Fall and Spring periods were *Regard; Regard and Vocalization, Regard, Vocalization, and Parallel Activity* (Figure 2*a*, page 449) Of the 1726 maintained contacts, 72 1 per cent were of one or another of these three pattern types. The five remaining types appeared with average frequencies of from 0.6 per cent to 7 6 per cent, slightly higher or lower with variations in age groups, the highest reached by any being 13 3 per cent

In Table 7 are listed the ratios of the number of contacts proving successful to the total number listed for each type, i e , the percent-

TABLE 6

DISTRIBUTION OF MAINTAINED CONTACTS AMONG VARIOUS TYPES

	Entire group 21			Two-year olds 7			Three-year olds 7			Four-year olds 7		
	Total	Fall	Spring	Total	Fall	Spring	Total	Fall	Spring	Total	Fall	Spring
*Types of patterns**												
Regard	34 0	37.2	30.2	32 9	41 2	23 0	39.9	40 0	39 7	28 8	31 4	25 8
Regard & Vocalization	21 1	18 7	23 9	14.2	10.3	18 8	20 0	18 8	21 4	27 5	25.2	30 4
Regard & Physical Contact	7 6	9 9	5.0	13 3	13.0	13 7	7 8	12 4	2 6	3 1	5 0	0 7
Regard & Parallel Activity	7 4	7 4	7 4	10 9	9 9	11 9	8 2	9 1	7 3	3 9	3 8	4 0
Regard & Cooper Activity	0 6	0 1	1 2	0 4	0 4	0 5	0 8	0 0	1.7	0 7	0 0	1.4
Reg., Voc, & Physical Cont	7 3	6 8	8 1	9 8	8 8	11 0	5.5	4 6	6.7	7 3	7 3	7 2
Reg, Voc., & Parallel Act	16.9	15 0	19 1	17 5	15 3	20.2	12 6	8 8	16 7	20 9	20 8	21 0
Reg, Voc., & Cooper Act	4 9	4 9	4 9	1 0	1 1	0 9	5 1	6 4	3 7	7 8	6 4	9 4

TABLE 7

PERCENTAGE OF SUCCESS PER TYPE OF MAINTAINED CONTACT

	Entire group 21			Two-year olds 7			Three-year olds 7			Four-year olds 7		
	Total	Fall	Spring	Total	Fall	Spring	Total	Fall	Spring	Total	Fall	Spring
Types of patterns												
Regard	0.2	0.3	0 0	0 0	0 0	0 0	0 4	0.7	0 0	0 0	0 0	0 0
Regard & Vocalization	*6.9*	*7 4*	*6 3*	*4 4*	*0 0*	*7 3*	*10.3*	*14 5*	*6 3*	*5 3*	*4 7*	*5 9*
Regard & Physical Contact	3 8	3 2	5 0	4 7	2 9	6 6	4 1	4 9	0 0	0 0	0 0	0 0
Regard & Parallel Activity	48 4	39 1	59 3	59 6	53 9	65.4	36 5	30 0	45 4	50 0	30 7	72 7
Regard & Cooper Activity	*90 9*	*100 0*	*90 0*	*100 0*	*100 0*	*100 0*	*80 0*	*0 0*	*80 0*	*100 0*	*0 0*	*100 0*
Reg, Voc, & Physical Cont.	10 3	17 5	3 1	17 0	30 4	4.2	8 6	20 0	0 0	4 4	4 0	5 0
Reg, Voc, & Parallel Act	78 7	67 1	89 4	75 0	60 0	88 9	82 3	79 3	84 0	79 1	66.2	94.8
Reg, Voc, & Cooper Act	*97 6*	*97 8*	*97 4*	*100 0*	*100 0*	*100 0*	*96 9*	*100 0*	*90 9*	*97 9*	*95 4*	*100 0*

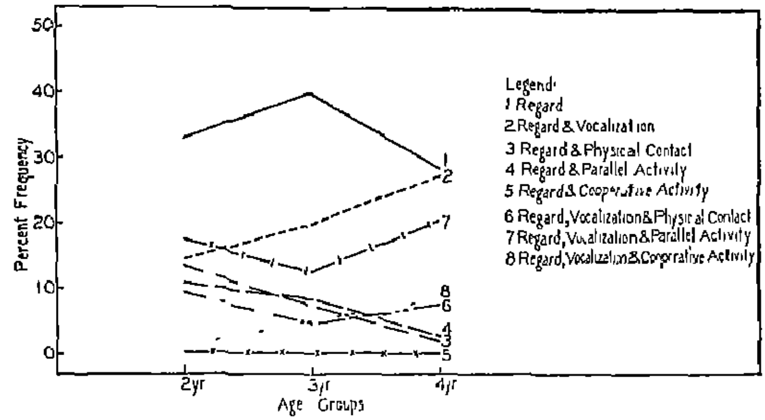

FIGURE 2*A*

age of success in maintaining group contacts per type. As was found for approaches, the various pattern types proved to be either highly successful or highly unsuccessful at all age levels and both in the Fall and the Spring. Four types showed success above 50 per cent (three of which were above 78 per cent) and the remaining four *types showed success of only 0.2 per cent to 10.0 per cent* (Figure 2*b*, below) *Regard, Vocalization, and Cooperative Activity* had

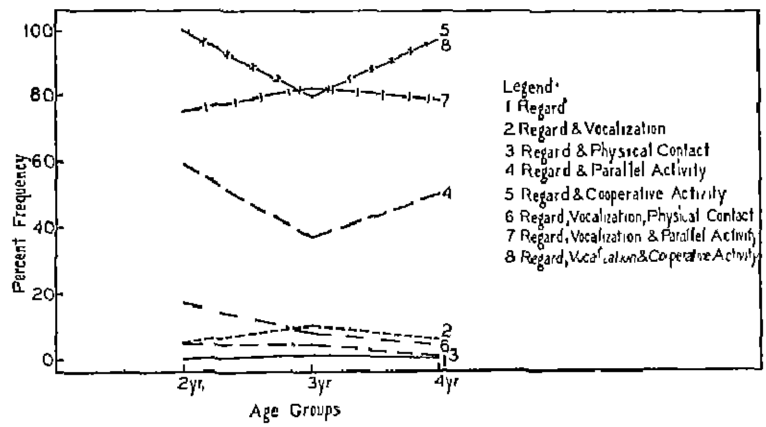

FIGURE 2*B*

a 97 6 per cent success; *Regard and Cooperative Activity,* 90.9 per cent; *Regard, Vocalization, and Parallel Activity,* 78 7 per cent; *Regard, and Parallel Activity,* 48.4 per cent. Among those with low percentages were: *Regard,* 0.2 per cent; *Regard and Physical Contact,* 3.8 per cent; *Regard and Vocalization,* 6.9 per cent; *Regard, Vocalization, and Physical Contact,* 10 3 per cent. The "all-or-none" principle applied to the patterns for the maintenance of *group* contacts as it did to patterns for the initiation of successful contacts.

The types of maintained contacts which proved successful retained their success potentialities with all the subjects—the twos, as well as the threes and fours—and both in the Fall and Spring, the types unsuccessful remaining unsuccessful at all times and at all age levels The question arises: Might not the factors underlying the maintenance of *group* contacts be fairly independent of the factor of age level and of the factor of existing social relationships within the group?

Data on the average length of a maintained contact and on the average number in a group will be presented in the section which deals with age level differences, page 452

3. *Conclusions* An attempt was made to discover some of the factors underlying the maintenance of *group* contacts Data showed that pattern types which included *Regard, Vocalization, and Cooperative Activity* or *Regard, Vocalization, and Parallel Activity* resulted almost universally in success. Since *Regard and Cooperative Activity* and *Regard and Parallel Activity* without the accompanying vocalization also showed a high probability of success, might it not be said that the two elements appearing one or the other in most of the successful patterns—Cooperative Activity and Parallel Activity—were the important factors underlying the maintenance of *group* contacts.

Results showed consistently the success of these factors—Cooperative and Parallel Activity—when used as a means of maintaining *group* contacts at any of the age levels, at either the Fall or Spring observation periods when the previous interrelationships between the subjects involved might have had some influence, by either the most maladjusted child or by the one showing the best personality adjustment, by the child with the highest intelligence quotient and by the child with the lowest (all IQ's included in the study were above

100). Success seemed to be dependent, to a greater extent, on techniques used rather than on personality patterns involved

The question raised as to the relative importance of maturation and learning by experience in the maintenance of *group* contacts will be discussed in another section, on this page

Analysis showed: (*a*) that 61 per cent of his free play time was spent by the preschool child in social play, (*b*) that of the time spent in social play, 61 9 per cent was of the type of *group* play aimed for in Nursery School Education. It was also found that 70.2 per cent of the contacts maintained by the preschool child were of the type found to be almost certain of failure in the maintenance of *group* contacts—*Regard; Regard and Vocalization, Regard and Physical Contact, Regard, Vocalization, and Physical Contact.* The preschool child seemed to be at the beginning stages of social interrelationships

CORRELATED QUESTIONS

1. *Maturation and Learning by Experience.* Data relevant to the question of maturation and learning by experience may be seen in Tables 2 and 5 (pages 440 and 446) Although there *was* an increase with age in the total number of contacts initiated and the total number of seconds in social contact (trend upward with negative acceleration following the typical growth curve attributed primarily to the effects of maturation), it was noted that in the Fall the percentage of success in initiating and maintaining *group* contacts did not show this gradual increase with age. The percentage of success for the two-year olds was 21 7 per cent; for the three-year olds, 21 4 per cent; for the four-year olds, 23.2 per cent. Progress was shown over the six-months period in nursery school for all age groups Furthermore the success attained by the two-year olds in the Spring was greater than that of the three-year olds and even the four-year olds in the Fall. Similarly, the three-year olds showed greater success in the Spring than did the four-year olds in the Fall It was true that the four-year olds showed the greatest progress over the six months, an increase of 15 7 per cent and 19 9 per cent respectively for successful approaches and for maintained *group* contacts, the two-year olds were next in order of progress, 9.8 per cent and 22.5 per cent respectively, the three-year olds were last, 5 8 per cent and 7 5 per cent respectively Had the

progress been due solely to maturation, would not the three-year olds have shown greater progress than did the two? This latter fact plus the one that success in social contacts did not necessarily increase consistently with age seemed to indicate that maturation alone was not responsible for success in social relationships

To conclude: It would seem that definite progress may be achieved through nursery school guidance in the development of social behavior A 10 per cent average increase in the initiation of successful contacts and a 16 per cent average increase in the time spent in *group* contact was found after six months in nursery school. In the Fall, the preschool child participated in *group* play during 29 per cent of his free play time; in the Spring, 46 per cent. Similar effects of learning were evident at the two- and three-year levels as well as at the four-year level

Learning by experience the techniques of successful social adjustment seemed possible at the two-year level Cooperative Activity and Parallel Activity were established as two of these techniques.[2]

2. *Age Level Differences.* Restating first the major items common to the various age levels, we found:

a Pattern types used most frequently—*Regard, Regard and Vocalization, Regard and Parallel Activity*—occurred as the three most frequent at all three age levels.

b Types proving most successful—*Regard, Vocalization and Cooperative Activity; Regard, Vocalization, and Parallel Activity, Regard and Cooperative Activity, Regard and Parallel Activity*—were most successful at all three age levels.

c Success in the Fall and progress from Fall to Spring were shown at all three age levels in almost equal amounts

Yet, there were some slight differences in the two-, three-, and four-year-old social behavior patterns which though not statistically significant at these age levels are of qualitative interest:

a. Four-year olds made a greater number of approaches and spent a larger amount of time in social contact than did the three-

[2]The advisability of speeding up social behavior development by teaching, i e, lessening the amount of trial and error the child must go through, was not the issue. The facts were established that teaching was possible and that there were techniques for establishing and maintaining successful social relationships fairly independent of the factors of individual personalities and age levels

year olds and correspondingly, the three-year olds more than the twos.

b. Concerning the 20 odd per cent of those patterns appearing infrequently—*Regard and Physical Contact, Regard and Cooperative Activity, Regard, Vocalization, and Physical Contact; Regard, Vocalization, and Parallel Activity; Regard, Vocalization, and Cooperative Activity*—at all three age levels, the two-year olds used more often those involving physical contacts; the threes and fours, those involving cooperative activity

c. The average length of a maintained contact increased with age For the two-year olds, it was 48 sec, for the three-year olds, 59 sec., for the four-year olds, 79 sec

d. The average size of the social group increased with age The social group at the two-year level averaged 2 30 members; at the three, 2.50 members, at the four, 2 62.

e Sociability indices increased with age (The index was determined for each subject by adding to the total number of other children he contacted throughout his 7200 seconds of observation the total number of times he appeared in a social contact recorded during the two-hour observations of the other twenty subjects.) Indices at the two-year level ranged from 600 to 1032 with a mean of 797 0, at the three, from 1104 to 1878, with a mean of 1364 3; at the four, from 1325 to 3189, with a mean of 2037 9

To conclude: There was an increase with age in the number of social approaches made, in the percentage of time spent in social contact, in the more frequent use of Cooperative Activity and less frequent use of Physical Contact as a technique, in the average length of a maintained contact, in the number of children participating in one social relationship, and in the sociability index. These changes may be due to maturation It may be that the two-year-old pattern has some limits set up by maturation However, the data tend to show that *success* in social relationships, the ability to turn an approach into a successful one and a maintained contact into a *group* contact may be influenced through learning by experience and that this success was as possible at the two-year level as at the three- and four-year levels.

Summary and Conclusions

An attempt was made to discover some of the factors underlying the initiation of *successful* contacts and the maintenance of *group* contacts A successful contact, as here defined, was one which resulted in the establishment of a *group* relationship between two or more children, bringing them functionally and spatially together with some common underlying aim or interest though not necessarily of the overt type. This interrelationship has potentialities for cooperation within the group both along the road toward and in the attaining of the goal. Moreover, there will be acceptance of each member by the others—a positive feeling toward each other. Such a group may have destructive aims as regards the rest of society, yet, so long as among the members similar aims, mutual interest and aid in attaining a goal are evident, these members are considered a *group*.

The investigation was carried through at the Vassar College Nursery School during the year 1933-1934. The 21 children in attendance at the school were used as subjects. Their chronological ages ranged from 2 years, 0 months to 4 years, 9 months, their IQ's from 103 to 141.

A two-hour observation (24 five-minute observations) was made of each of the subjects; one hour in the Fall, during the first three weeks at nursery school, the other in the Spring, six months later. Records timed to ten-second intervals were kept of significant items in the social behavior pattern of the subject and were supplemented by a complete running diary record of the five minutes

Emphasis was placed on social behavior items manifested rather than on the individual's personality. In the analysis of the data, separate items of social behavior were studied always in context, a simple pattern of from one to three basic items adopted for use. Data obtained for the total group and for the separate two-, three-, and four-year age groups permitted the study of age level variations in addition to behavior items. Data obtained for the total period of observation and for the Fall and Spring periods separately permitted the study of changes over a six-months period in nursery school.

A total of 1976 approaches was observed and the success of each in establishing a *group* contact noted. Similarly, 91,980 seconds of

social contact—the time accumulation of 1726 maintained contacts —were observed and the percentage of the time in *group* contact noted Of the total number of contacts initiated, 27 3 per cent were successful. Of the total free play time, 37.8 per cent was spent in *group* play.

Distribution of the 1976 approaches and the 1726 maintained contacts among the eight pattern types was made. The percentage of success per type was found Results showed that the factors of Cooperative Activity and Parallel Activity seemed to determine the success in the initiation of and in the maintenance of *group* contacts. At all three age levels, at both the Fall and the Spring observation periods (when, at the latter, the factor of pre-established inter-social habit patterns was involved), with either the well-adjusted or maladjusted child, with either the highly intelligent or average child, the pattern types of approach and of maintained contacts which included as an item, Cooperative Activity or Parallel Activity, retained high probability of success and those which did not invariably failed to establish *group* contacts.

Child A, most socially accepted, was the one using most frequently the patterns which proved to be successful while Child B, least socially accepted, was the one using least often those patterns. Since both children, A and B, when using types shown to be of little positive value in establishing *group* contacts, were equally unsuccessful, would it not seem that success in social relations was to a greater extent influenced by the techniques used than by the personality of the subject?

Results of the Fall observation showed the four-year olds to be not more successful in establishing *group* contacts than were the two-year olds. Progress over the six-months period was shown by both the two- and four-year olds. Would it not seem that in the establishment of successful social contacts, the factor of learning by experience was perhaps even more important than the factor of maturation? Maturation did seem to set a limit to the number of approaches made, to the length of time in social contact, to the duration of a contact, and to the number of children in a group (all of which factors do show a definite increase with age) However, within the limits set by maturation, the proportionate success in the establishment of successful *group* contacts did not show this increase with age—this effect of matura-

tion. The two-year olds, when using techniques shown by the data to be among those underlying the establishment of successful social contacts, were as successful as four-year olds Two-year olds did learn techniques for establishing *group* contacts. Two of these techniques were to make approaches through Parallel Activity and Cooperative Activity.

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UNE ÉTUDE DE QUELQUES-UNES DES TECHNIQUES À LA BASE DE L'ÉTABLISSEMENT DES CONTACTS SOCIAUX RÉUSSIS AU NIVAU PRÉSCOLAIRE

(Résumé)

On a fait une observation durant deux heures du comportement social de chacun de 21 enfants d'âge préscolaire pour découvrir les techniques à la base des contacts sociaux réussis L'étude des données sur les 7 enfants âgés de deux ans, les 7 âgés de trois ans, et les 7 âgés de quatre ans a donné des resultats sur les variations du niveau d'âge. Une comparaison des

observations faites en automne avec celles du printemps a *montré* des changements du comportement social dans une période de six mois dans l'école maternelle On a gardé les formes du comportement dans l'analyse pour empêcher une évaluation "a priori" des points individuels sur le succès ou l'insuccès du contact

Les données ont montré que lorsque l'on a *employé l'activité* coopérative ou l'activité parallèle comme techniques, le contact initié a résulté dans un contact *collectif* de la sorte voulue par l'enseignement de l'école maternelle Les enfants de 4 ans n'ont pas beaucoup plus réussi que ceux de 2 ans. Tous les niveaux d'âge ont montré des progrès entre l'automne et le printemps Le succès dans l'établissement des contacts semble plus dependre des techniques employées que des caractéristiques de la personnalité des sujets, de l'âge, ou de l'état antérieur des relations. L'enfant d'âge pré scolaire, en employant le plus fréquemment le simple regard ou la vocalisation comme techniques d'approche, n'a réussi que 27,3% du temps.

MAILAY

EINE UNTERSUCHUNG VON EINIGEN DER DER FESTSETZUNG *ERFOLGREICHER SOZIALER BEZIEHUNGEN BEI VORSCHUL-* PFLICHTIGEN KINDERN UNTERLIEGENDEN METHODEN

(Referat)

Eine zweistundige Beobachtung des sozialen Verhaltens jedes von einundzwanzig vorschulpflichtigen Kindern *wurde ausgefuhrt, um die der Festsetzung* erfolgreicher sozialer Beziehungen unterliegenden Methoden zu entdecken Eine Untersuchung der Daten uber die sieben zwei-, sieben drei-, und sieben vierjahrige Kinder ergab Resultate uber die Altersniveauvariationen Ein Vergleich der in Herbst gemachten Beobachtungen mit den im Fruhling gemachten Beobachtungen wies Veranderungen des *sozialen verhaltens* uber einen Zeitraum von sechs Monanten in der Schule auf Die Verhaltensgebilde wurden in der Analyse behalten, um das Geben von irgendeinem "a priori" Gewicht den verschiedenen Einzelheiten uber Erfolg oder Misserfolg der Beziehungen zu vermeiden.

Die Daten zeigen, dass, wenn zusammenwirkende oder zusammenlaufende Tatigkeit als Methode gebraucht wird, die angefangene Beziehung in eine Gruppenbeziehung ubeiging, worauf die Pflegeerziehung zielt Vierjahrige Kinder waren nicht viel erfolgreicher als die zweijahrigen Alle Gruppen wiesen Fortschritte vom Herbst bis zum Fruhling auf Der Erfolg in der Festsetzung von Beziehungen schien mehr von den gebrauchten Methoden abzuhangen als von den Personlichkeitseigenschaften, dem *Alter, oder von dem vorherigen Stand des Verhaltnisses der Vpn.* Das vorschulpflichtige Kind beim Gebrauch am haufigsten von einfacher Betrachtung oder Volkalisation als Methoden, war nur 27,3% der Zeit erfolgreich

MAILAY

A STUDY OF THE CONFUSING LETTERS B, D, P, AND Q*

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The data to be presented in this study were gathered at the same time and from the same children as those which formed the basis of "A Study of Reversals in Young Children" (1) In the latter the extent to which young children made reversal errors in a test of form discrimination and in a test of word discrimination was analysed In this, the third and last test of the series, the extent to which these same young children confused *b* with *d*, and *p* with *q*, reversal errors in a letter discrimination test as it were, was studied

The test was given to all the kindergarten and first-grade pupils attending the four public schools with which the writer was connected Practically all of these pupils had been given Stanford-Binet tests during the year by the writer The Letter Perception Test was given at a later time of the same day as the other two tests, the order of presentation being Form Perception Test, Word Perception Test, then Letter Perception Test, so as not to make the children letter conscious at the start Complete data for the letter test are available for 48 kindergarten and 111 first-grade children, 159 in all. From Table 1 it will be seen that the distribution of intelligence of these children is a very normal one

TABLE 1
DISTRIBUTION OF INTELLIGENCE BASED ON STANFORD-BINETS

N	Pupils	Mean CA	Mean MA	Mean IQ	Sigma
159	Total (kgn. and gr. 1)	6 yrs. 5 02 mos	6 yrs. 4 38 mos.	99 80±0 78	14 72±0.56
111	First-grade	6 yrs 8 55 mos	6 yrs 7 15 mos	99 03±0 96	14 97±0.67
48	Kindergarten	5 yrs. 8 88 mos	5 yrs 10 88 mos.	101 79±1 37	14 03±0 97
62	First-grade boys	6 yrs 9 08 mos	6 yrs. 6 08 mos	97.16±1 26	14 67±0 89
49	First-grade girls	6 yrs 7.89 mos	6 yrs. 8 5 mos.	101 39±1.47	15 24±1.04

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The Letter Perception Test devised for this experiment was in the nature of a cancellation test A certain letter was printed in large black type at the left side of a sheet of paper After it a "box" was drawn containing four rows of ten letters each Among these letters were five identical to the given letter, five of the letter most likely to be confused with it (the mirrored opposite in the case of *d*, *q*, and *b*), several each of other possibly confusing letters including several tall letters in case "tallness" was an important factor in letter recognition, while the remainder were randomly selected letters. The children were instructed to look at the given letter, then find every one exactly like it in the box and mark it when they found it There was one practice exercise The test was given as a group test There were no time limits, all children being given sufficient time to complete it In this way the letters *d*, *e*, *n*, *q*, and *b* were studied. Although the chief interest was to see the extent to which *d* would be confused with *b*, and *q* with *p*, it was also thought advisable to see if *d* would also be confused with *p* and *q*, as well as *q* with *d* and *b*. It was also thought that *e* might be easily confused with *c* and *o*, and *n* with *u*, *m*, and *h*, so these were included in the study, and a test with *b* was added as a check on the test with *d*

The writer had expected to be able to tabulate the number of each type of error made, but it was soon evident that many of these young children were unable to persist in the task until they had found every letter of the kind they were seeking Some were content when they had marked only two or three. Accordingly it was unsafe to base calculations on the number of errors made The following procedure has therefore been used A child has been credited as having confused *b* with *d* whether he marked one *b* or five *b*'s It was a rare child, of course, who marked only one

A few children made other errors than the ones presented in the following tables, but since so few made the same mistake these errors must be regarded as chance errors and, in some cases, as perseverations from the previous test More consistent errors, but not sufficiently numerous to tabulate, were as follows: Three pupils confused *d* with *h*, five *d* with *f*, three *q* with *h*, four *b* with *h*, and one *b* with *f* The letter *e* was confused so seldom with any letter that it has been omitted from the tables The letter *m* was not confused with *n* so it has also been omitted In marked contrast are the confusions presented below.

TABLE 2

PERCENTAGE OF KINDERGARTEN AND FIRST-GRADE PUPILS MAKING EACH TYPE OF ERROR

Grade	N	d-b	d-p	d-q	n-u	n-h	q-p	q-b	q-d	b-d	b-p	b-q
Kgn	48	93.8	50.0	35.4	25.0	35.4	95.8	43.8	27.1	87.5	39.6	41.7
Grade 1	111	64.9	18.9	13.5	9.9	13.5	62.1	10.8	13.5	60.4	18.9	15.3

From Table 2 it is seen that a much larger percentage of kindergarten than first-grade children made every type of error studied Practically all the kindergarten children confused *d* with *b*, *q* with *p*, and *b* with *d* A smaller but substantially large percentage of first-grade pupils made these same errors. The letter *n* was confused with *h* to a greater degree than with *u*.

TABLE 3

PERCENTAGE OF PUPILS AT EACH CA LEVEL MAKING EACH TYPE OF ERROR

CA	N	*d-b	d-p	d-q	n-u	n-h	q-p	q-b	q-d	b-d	b-p	b-q
5-0 to 5-5	14	78.6	50.0	28.6	21.4	28.6	85.7	28.6	28.6	78.5	35.7	35.7
5-6 to 5-11	40	85.0	37.5	25.0	20.0	27.5	90.0	37.5	22.5	80.0	30.0	30.0
6-0 to 6-5	34	70.6	20.6	20.6	5.9	5.9	64.7	8.8	8.8	55.9	11.8	20.6
6-6 to 6-11	38	76.3	26.3	23.7	18.4	28.9	68.4	23.7	21.1	71.1	26.3	21.1
7-0 to 7-5	16	62.5	12.5	0.0	6.3	12.5	56.3	0.0	6.3	56.3	37.5	18.8
7-6 to 7-11	8	37.5	25.0	0.0	12.5	12.5	50.0	25.0	12.5	37.5	12.5	0.0
8-0 to 8-5	6	66.7	16.7	16.7	0.0	16.7	66.7	0.0	0.0	83.3	16.7	0.0
8-6 to 8-11	2	50.0	0.0	0.0	50.0	0.0	50.0	0.0	50.0	100.	0.0	50.0
9-0 to 9-5	0	—	—	—	—	—	—	—	—	—	—	—
9-6 to 9-11	0	—	—	—	—	—	—	—	—	—	—	—
10-0 to 10-5	1	100	100	100.	0.0	0.0	100	0.0	100	100	100	100.

*"d-b" means the pupil marked *b* instead of *d*. Similarly "d-p" means *p* was marked instead of *d*; "n-u" means *u* was marked instead of *n*, etc

Table 3 shows the percentage of children at each chronological age level who made the various types of errors. Although, generally speaking, there was a decrease in the number of errors with increasing chronological age, it was by no means a consistent decrease. It is interesting to note from Table 4 that it was not until a chronological age of seven and one-half years was reached that 50 per cent of the pupils of any age level were able to select *d*, *q*, and *b* without error The letter *n* was apparently more easily identified

In striking contrast are Tables 5 and 6 which reveal a marked correspondence between increase in mental age and decrease in errors, particularly of the *d*, *q*, and *b* variety. It is interesting to note that

TABLE 4

PERCENTAGE OF PUPILS AT EACH CA LEVEL SELECTING *d, n, q,* AND *b* WITHOUT ERROR

CA	N	d only	n only	q only	b only
5-0 to 5-5	14	14.3	50 0	14 3	14 3
5-6 to 5-11	40	10 0	52 5	10.0	12 5
6-0 to 6-5	34	26 5	76 5	32.3	41.2
6-6 to 6-11	38	21 1	65.8	31.6	26 3
7-0 to 7-5	16	37 5	81 3	43 8	25 0
7-6 to 7-11	8	50 0	75 0	50 0	50 0
8-0 to 8-5	6	16.7	66 7	16 7	16 7
8-6 to 8-11	2	50.0	50 0	50 0	0.0
9-0 to 9-5	0	—	—	—	—
9-6 to 9-11	0	—	—	—	—
10-0 to 10-5	1	0 0	0 0	0 0	0.0

TABLE 5

PERCENTAGE OF PUPILS AT EACH MA LEVEL MAKING EACH TYPE OF ERROR

MA	N	d-b	d-p	d-q	n-u	n-h	q-p	q-b	q-d	b-d	b-p	b-q
4-6 to 4-11	8	100 0	62 5	25 0	12 5	37.5	100 0	62 5	50 0	87 5	50 0	50 0
5-0 to 5-5	15	86 7	53 3	40 0	46 7	26 7	86 7	46 7	46 7	93 3	40 0	40 0
5-6 to 5-11	30	86 7	46.7	33.3	23 3	40 0	83 3	26 7	16 7	80 0	33 3	40 0
6-0 to 6-5	34	79 4	23 5	14 7	8 8	11 7	82 4	8.8	11 7	79 4	20.6	14.7
6-6 to 6-11	33	72 7	21.2	18 2	9 1	15 1	69.7	18 2	15 1	60.6	24 2	18.2
7-0 to 7-5	23	56 5	8 7	4 3	8 8	13 0	56 5	17 4	13.0	56.5	17 4	17.4
7-6 to 7-11	11	36 3	9 1	18 2	0.0	9.1	36.4	0 0	0 0	27 3	9.1	0 0
8-0 to 8-5	4	25 0	0.0	0 0	0 0	0 0	25 0	0 0	0 0	25 0	0 0	0 0
8-6 to 8-11	0	—	—	—	—	—	—	—	—	—	—	—
9-0 to 9-5	1	100 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0.0	0 0

TABLE 6

PERCENTAGE OF PUPILS AT EACH MA LEVEL SELECTING *d, n, q,* AND *b* WITHOUT ERROR

MA	N	d only	n only	q only	b only
4-6 to 4-11	8	0 0	37 5	0 0	0 0
5-0 to 5-5	15	0.0	26 7	6.7	0 0
5-6 to 5-11	30	6 7	43 3	16 7	10 0
6-0 to 6-5	34	14 7	70 6	17 6	14 7
6-6 to 6-11	33	25 4	81.8	30 3	36 4
7-0 to 7-5	23	43 5	73 9	39 1	39 1
7-6 to 7-11	11	54 5	90 9	63 6	63 6
8-0 to 8-5	4	75 0	100 0	75.0	75.0
8-6 to 8-11	0	—	—	—	—
9-0 to 9-5	1	0.0	100 0	100 0	100 0

it was not until a mental age of eight years was reached that 75 per cent of the pupils made no error in selecting *d*, *q*, and *b*, while a mental age of six and one-half years was sufficient for *n*.

In analysing these tables to see where the greatest decrease in error comes, one cannot but be struck with the way in which the errors fall into groups The greatest decrease for *d-b*, *q-p*, and *b-d* is between the mental age intervals 7-0 to 7-5 and 7-6 to 7-11. The greatest increase in ability to select *q* and *b* without error also occurs at this point while that for *d* comes six months later All but two of the other types of error fall between the 5-6 to 5-11 and 6-0 to 6-5 intervals, and these come six months earlier From this one cannot but conclude that growth in ability to distinguish between the letters of the alphabet is closely allied with increasing mental age, that the majority of the letters are easily distinguished, that the *d-p*, *d-q*, *n-u*, *n-h*, *q-b*, *q-d*, *b-p*, and *b-q* confusions grow considerably less between the mental ages of five and six years, but it is not until a mental age of at least seven and one-half years is reached that there is a distinct increase in ability to avoid *d-b*, *p-q*, and *b-d* confusions, and in ability to select *d*, *q*, and *b* without error. At this point it is worth noting that in the writer's earlier study the greatest decrease in form and word reversal errors appeared to fall between the mental age groups 5-0 to 5-5 and 5-6 to 5-11.

It has long been known to educators that young children confuse *b* with *d*, and *p* with *q* very readily, and this matter has received fresh attention in recent years from investigators in the field of reading disability. Accordingly it might not be out of place at this juncture to consider what may be involved in this phenomenon. Orton has advanced his theory of lack of cortical dominance to explain why some children read letters and words backwards The following quotation sets forth his viewpoint very clearly:

> Further, the difficulty in our cases of reading disability in differentiating p from q, and b from d and their tendency to confuse palindromic words like not and ton and on and no suggest that the mnemonic record exists in the brain in both orientations.
>
> Letters are in themselves merely objects until they have come to acquire meaning through sound associations or through association in groups of sounds which constitute a word. We would therefore assume that in the process of early visual

> education, the storage of memory images of letters and words occurs in both hemispheres, and that with the first efforts at learning to read the external visual stimuli irradiate equally into the association cortices of both hemispheres, and are there recorded in both dextrad and sinistrad orientation Images of objects require no definite orientation for recognition or differentiation, but when we are dealing with letters which have come by custom to be used in one orientation only, it is clear that the orientation of the recalled image must correspond with that of the presented symbol, or confusion will result
>
> This suggests the hypothesis that the process of learning to read entails the elision from the focus of attention of the confusing memory images of the nondominant hemispheres which are in reversed form and order, and the selection of those which are correctly oriented and in correct sequence (3)

Orton's theory, expressed above, would explain why *d* is confused with *b*, but it is difficult to see how it would explain why *d* is confused with *p* and *q*. If the letter *d* is swung on its own axis through an angle of 180 degrees it becomes *p*, and if it is turned completely over in an up and down direction it becomes *q*. Both of these positions could therefore be considered upside down inversions of *d*. Although the reversal errors are much more frequent than the inversion errors, the writer is inclined to believe they are part of the same phenomenon

Dearborn (2) distinguishes between reversals, such as *not* for *ton*, and alterations in correct sequence of letters, such as *framing* for *farming*. He states

> Reversals are associated with left-handedness and left-eyedness, and the alterations are associated with deviations from the usual conditions of lateral dominance of hand and eye, as in ambidexterity of hand and eye, change of handedness and eyedness, and the combination of right-handedness and left-eyedness or of left-handedness and right-eyedness In a large percentage of the cases of alteration and in some cases of reversal a condition of muscular imbalance of the eyes (heterophoria) seems, as has been shown by Charles Selzer, to be a complicating factor

Unfortunately the writer did not study the handedness and eyedness of the pupils used in this experiment and so is unable to throw

any light on this angle of the problem. However, the almost universality with which the kindergarten children of this study made reversal errors, if supported by further investigations, and the very early age at which handedness and eyedness appear to be established, judged by such experimental literature as is available, would seem to be at variance with the above theories. There is much need for further extensive investigation to determine the relationship, if any, between reversal errors in reading and handedness and eyedness.

The writer, having approached this problem of reversals as a result of her work with young normal children, has suggested the possibility that words to young children are independent of their absolute spatial position, and so a young child can recognize a word no matter in what position it may lie In her previous study she showed that the tendency to make reversal errors in a test of geometric forms and in one of words was practically universal with kindergarten children and that it decreased with increasing mental age and experience. This experiment with letters shows similar results There is a tendency for certain letters to be confused with each other and some of these confusions persist longer than others The upside down confusion, *d-p*, *d-q*, *q-b*, *q-d*, *b-p*, *b-q*, and *n-u*, is apparently largely overcome between the mental ages of five and one-half and six years, but the left-to-right confusion not until a mental age of seven and one-half years or more. The writer has occasionally used this letter test with first-grade children with a mental age of more than six years who were failing to learn to read. Sometimes a child would mark the *b*'s as well as the *d*'s, then stop and erase the *b*'s, saying: "This faces this way and that faces that way" Other children would mark all the *b*'s and *d*'s At the conclusion of the test the writer would point to the "model" letter, then to one after another of the letters marked by the child, asking: "Is this the same as that?" Some children replied in the affirmative to all. One or two said "Yes," then added "This faces this way and that faces that way." These observations were made on only one or two isolated cases but seemed to indicate that the child noted the difference in orientation of the letters but did not consider that this fact made them different. This type of recognition would seem to be similar to that in which the child recognizes a chair no matter in which way the seat is facing. A chair turned upside down might possibly be another matter, however. The upside down position dis-

torts an object more than the left to right inversion. Although some children might recognize it as a chair, it is conceivable that others would fail to see its resemblance in such a position.

In her previous study the writer found that 8 per cent more boys than girls made form reversal errors and 10 per cent more word reversal errors. This indicated the possibility of a sex difference in the perception of words which might have some bearing on the fact that more boys than girls develop into reading problems. These data were analysed to see what light they shed on this same subject, and are presented in Table 7

TABLE 7
PERCENTAGE OF BOYS AND GIRLS MAKING EACH TYPE OF ERROR

	Kindergarten		First Grade	
Error	Boys (23)*	Girls (25)	Boys (62)	Girls (49)
d-b	91 3	96 0	72 6	55.1
d-p	47 8	52 0	24 2	12.2
d-q	39.1	32.0	16.1	10.2
n-u	26 1	24 0	16 1	2 0
n-h	34 8	36 0	8 1	20.4
q-p	95 6	96 0	75 8	44 9
q-b	30.9	56 0	11 3	10 2
q-d	17 4	36 0	16 1	10 2
b-d	86.9	88.0	66 1	53 0
b-p	34 8	44 0	24 2	12 2
b-q	39 1	44 0	22 6	6 1

*Figures in parentheses indicate the number of subjects

It is at once seen that there is no apparent sex difference among the kindergarten boys and girls. This is not unexpected since practically all the kindergarten boys and girls made the *b-d* and *p-q* errors, and so whatever is operating to produce these errors is common to all In striking contrast are the first-grade results, however A larger percentage of boys than girls made 10 out of the 11 types of errors studied The only item in which the girls were poorer was in the *n-h* error, which is a different type of error than the inversions involved in the others From Table 1 it is seen that the first-grade girls were slightly brighter than the first-grade boys, but the difference was less than the probable error of the score, and so

was probably not a significant difference. Accordingly, although the number of pupils is not large, the consistency with which the first-grade boys are inferior to the first-grade girls in discriminating between these letters would appear to indicate a genuine sex difference and so would confirm the findings with geometric forms and words

Summary and Conclusions

The purpose of this experiment was to determine with what letters and to what extent unselected young children confuse the letters *d*, *e*, *n*, *q*, and *b*, respectively, the chief interest being directed toward the reversal type of error.

A Letter Perception Test was devised for this purpose and given to 48 kindergarten and 111 first-grade children whose distribution of intelligence as measured by Stanford-Binet IQ's proved to be a very normal one.

The results revealed that a larger percentage of kindergarten than first-grade children made every type of error. Practically all kindergarten children confused *d* with *b*, *q* with *p*, and *b* with *d*. A smaller but substantially large percentage of first-grade children made similar errors.

The errors, with one exception, fell into two groups, namely, reversal errors and inversion errors. The one exception was the *n-h* error

There was a marked and consistent decrease in the percentage of children making errors with increase in mental age Between the mental ages of five and one-half and six years there was a marked decrease in the percentage of children making the following errors: *n-u*, *n-h*, *q-b*, *q-d*, *d-p*, *d-q*, *b-p*, *b-q*. The greatest increase in ability to avoid *d-b*, *p-q*, and *b-d* errors, and in ability to select *d*, *q*, and *b* without any error whatever, did not occur until a mental age of at least seven and one-half years had been reached

No evidence of a sex difference was found among the kindergarten children but a larger percentage of first-grade boys than first-grade girls made 10 out of the 11 errors studied. The one exception was the *n-h* error which is a different type of error from the others This consistent difference suggests the presence of a real sex difference and corroborates the indications of a sex difference found

by the writer in her study of form reversal and word reversal errors It has an important bearing on first-grade reading in view of the larger number of boys who present serious reading difficulties.

These data indicate that some letters of the alphabet are more difficult to discriminate than others The letters that are the most difficult to distinguish between are the pairs of letters that are the reversal of each other Letters that are the upside down inversion of others are also difficult to differentiate but not nearly so difficult as reversals. Increase in ability to discriminate letters comes with increasing mental maturity and experience. This would fit in with a genetic theory of form perception.

There are indications that children pass through certain stages before they are able to distinguish between *b* and *d*, *p* and *q*. In the first stage, for example, they confuse *b* with *d*, *p*, and *q*. Apparently the fact that all four letters consist of a circle and a stem is sufficient to establish their identity. In the second stage they confuse *b* with *d* but not with *p* and *q*. The direction of the stem is apparently a determining factor. In the third stage they consider *b* and *d* to be alike although they recognise that these letters face different ways In the final stage they recognise that *b* and *d* are actually different letters The above indicates that young children recognise letters independently of their absolute spatial position.

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UNE ÉTUDE DES LETTRES EMBROUILLANTES B, D, P, et Q

(Résumé)

On a fait cette expérience dans le but de déterminer avec quelles lettres et à quel degré les jeunes enfants non choisis embrouillent les lettres *d*, *e*, *n*, *c*, et *b*, respectivement, l'intérêt principal étant dirigé vers le type renversé d'erreur

Dans ce but on a fait un Test de Perception des Lettres et l'a fait subir à 48 élèves du jardin des enfants et à 111 élèves de première année de l'école élémentaire dont la distribution de l'intelligence, mesurée par les QI Stanford-Binet, s'est montrée très normale

Les résultats ont montré que plus des élèves du jardin des enfants que ceux de l'école élémentaire ont fait chaque type d'erreur A peu près tous les élèves du jardin des enfants ont embrouillé *d* avec *b*, *q* avec *p*, et *b* avec *d* Un pourcentage plus petit mais assez grand des enfants de l'école élémentaire ont fait des erreurs semblables Il y a eu une diminution distincte et constante du pourcentage des enfants qui ont fait des erreurs avec l'avancement de l'âge mental.

On n'a trouvé aucune évidence d'une différence de sexe parmi les élèves du jardin des enfants, mais un plus grand pourcentage des garçons que des filles ont fait dix sur les onze erreurs étudiées, la seule exception étant l'erreur *u-h* qui n'est pas un type d'erreur renverse ou inverti comme les autres Ceci corrobore les indications d'une différence de sexe trouvée par l'auteur dans son étude des erreurs renversées de forme et de mots

DAVIDSON

EIN STUDIUM ÜBER DIE VERWECHSLUNG DER BUCHSTABEN *B, D, P,* UND *Q*

(*Referat*)

Der Zweck dieses Experiments war die Festellung, mit welchen Buchstaben und zu welchem Grad unausgewahlte junge Kinder die Buchstaben *d, e, u, q,* und *b* verwechseln Das Hauptinteresse wurde auf den Vertauschungstyp von Irrtum gerichtet

Ein Buchstabenwahrnehmungstest wurde zu diesem Zweck aufgestellt und 48 Kindern des Kindergartens und 111 der ersten Stufe (first grade) gegeben, deren Intelligenzverteilung nach dem Stanford-Binet sich als normal zeigte

Die Ergebnisse zeigen, dass ein grosserer Prozentsatz der Kinder des Kindergartens als der Kinder der eresten Stufe jeden Typ von Irrtum machen. Fast alle Kinder des Kindergartens verwechselten *d* mit *b*, *q* mit *p*, und *b* mit *d* Ein kleinerer, aber betrachtlich grosser Prozentsatz der Kinder eresten Stufe machten ahnliche Fehler. Es gab eine deutliche und gleichmassige Abnahme des Prozensatzes der Kinder bei einer Zunahme des geistigen Alters, die Fehler machten

Kein Beweis eines Geschlechtsunterschiedes unter den Kindern des Kindergartens stellte sich heraus, aber ein grosserer Prozentsatz der Knaben als der Madchen machten zehn aus den elf untersuchten Fehlern, die eine Ausnahme war der Fehler mit *u-h*, der nicht ein Vertauschungs- oder Umstellungstyp von Irrtum ist, wie die anderen Dies bestatigt Andeutungen eines Geschlechtsunterschiedes, den von der Verfasserin in ihrem Studium uber die Form- und Wortvertauschungsirrtumer gefunden wurde

DAVIDSON

SHORT ARTICLES AND NOTES

A NOTE CONCERNING CEREBRAL DOMINANCE IN THE RAT

R Yorke Herren and Donald B Lindsley

The fact that the two halves of the brain are mirrored counterparts of each other, together with the reversals seen in reading, spelling, and stuttering disabilities, has led Orton (4-6) to postulate that a pattern established in the dominant hemisphere would, when activated, produce a response in harmonious orientation with the stimulus pattern, while the same pattern of the opposite or non-dominant hemisphere would, if activated uninhibitedly, produce a response the mirrored image of the stimulus pattern To test the hypothesis that comparable engrams in the two cerebral hemispheres, when activated, produce motor expressions which are mirrored counterparts of each other, the following experimentation was undertaken

The handedness of 16 mature male rats was determined after the method of Tsai and Maurer (9), a method which has been used by others, notably Peterson (7) The animals were starved for two days, and then placed in a round wire cage through the floor of which the round mouth of a bottle protruded about a quarter of an inch The bottle was filled with fine bread crumbs and the number of times the animal reached in with each hand for food was counted All animals were given 50 trials a day for six days, both before and after operation

With the exception of a few mixed responses on the first two days of testing, the rats all showed a definite preference for either the right or left hand Twelve of the rats were left-handed and four right-handed in this food-reaching test As shown by Peterson (8) in a recent study this does not necessarily mean that a rat manifesting preferential use of a hand on this test will do so in different situations However, since the preferential use of a hand in the food-reaching situation seems to remain stable in any one rat tested over a considerable period of time, and since the studies of Peterson as well as this one have shown that the destruction of an appropriate area of the cortex contralateral to the preferred hand will cause a gradual shift to the use of the other hand following the operation, we have assumed that handedness as manifested by food-reaching tests is an index to the dominant hemisphere

The animals, regardless of handedness, were then all trained to run a simple, inclosed maze (Figure 1), which when turned over afforded a maze pattern the mirrored counterpart of the original All animals were allowed to overlearn the maze in an effort to equate the dull with the more intelligent animals After the maze had been run for eight days with no improvement, the animals were operated

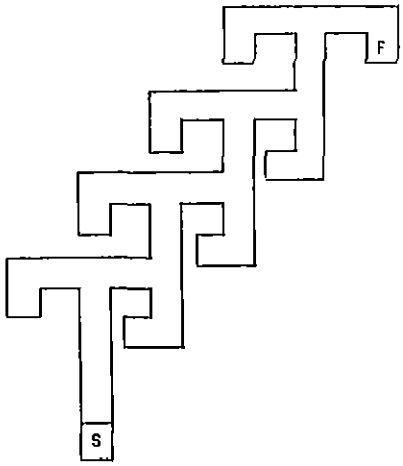

FIGURE 1

A SIMPLE, INCLOSED MAZE WHICH CAN BE TURNED OVER TO AFFORD A PATTERN OF THE OPPOSITE ORIENTATION

S is the starting chamber, *F* the food box

Under sodium amytal anaesthesia (6 mgms per 150 grams body weight, injected intraperitoneally) the dominant hemisphere, as indicated by the handedness, was exposed and cauterized as widely as possible The incisions were then closed under aseptic precautions and the animals allowed to recover. After a two-week convalescent period the animals were divided into two groups by random selection. One group ran a maze the mirrored image of the original, while the other group ran the maze in its original orientation In the post-operative maze running, no attempt was made to have both groups run their respective mazes perfectly, the experiment being terminated when the rats of one group successively ran the maze without bettering their scores in time or errors.

At the termination of the experiment each animal was autopsied Serial sections of the brain were cut, stained with cresyl violet, counter-stained with Morgan's stain, and examined microscopically to eliminate those animals with extracortical lesions and to determine the extent of cortical ablation. This was accomplished by cutting serial, coronal sections ten micra thick and drawing every tenth section. The amount of damaged and undamaged surface cortex was actually measured from these drawings No attempt was made to measure the hippocampal or concealed cortex The measurements were then expressed as the percentage destruction of the total neo-cortex of a hemisphere. It was found that the average

extent of destruction in the two groups of animals was very nearly the same, being 33.0 per cent (range 27.1 to 42.9) in the group running the maze in the original orientation and 32.4 per cent (range 21.0 to 39.0) in the group running the mirrored maze. The destructions in all cases involved chiefly the motor and common sensory areas of the cortex, although in every case the visual area was invaded to some extent and in a few cases the lesions extended into the auditory area.

If, according to Orton and others, the engramic representation in the non-dominant hemisphere, when freed largely from the influence of the dominant hemisphere, expresses itself in a motor pattern, the mirrored image of that which is the ordinary expression of the dominant hemisphere, we might expect that rats with a substantial percentage of their dominant hemisphere destroyed would show a better performance on the mirrored maze than the group delegated to run the maze in its original orientation. We have found, on the contrary, that at the end of the ninth trial all of the group running the maze in its original orientation had reduced their time and error scores to the level at which they completed their initial learning prior to the operation, whereas only one of the group running the maze in mirrored orientation had reached that level of efficiency. The average time and error scores for the former group at the end of the ninth trial following the operation were 4.5 seconds and 0 errors. The average scores for the latter group on the ninth trial were 12.0 seconds and 2 errors.

The one exception to violate the rule of poorer performance in the group running the mirrored maze, namely rat 5, had the least cortical destruction of any of the rats in either group—21 per cent. Although Lashley and Wiley (3) report in a recent study that there is no critical amount of destruction below which lesions are relatively ineffective, yet the continuous curve of such relationships which they present shows a markedly accelerated form for lesions above 15 to 20 per cent. Hence it is quite possible that rat 5 with as little as 10 to 11 per cent destruction (based, as Lashley's percentages were, upon the entire neo-cortex of both hemispheres) had sufficient amount of the dominant hemisphere left to enable him to learn the mirrored maze as a new pattern. In agreement with this explanation, rat 5 did not exhibit a complete transfer of handedness in the post-operative tests but manifested considerable degree of ambidexterity throughout. It is perhaps reasonable to suppose that the rest of the animals which performed on the mirrored maze had sufficient amount of the dominant hemisphere destroyed to render them incapable of such reorganization, and had only the engram of the non-dominant hemisphere to guide them. It is, of course, entirely possible that these rats might have learned the mirrored maze as a new pattern with the remaining portion of the dominant hemisphere, although the statistically significant tendency on the part of these animals to make errors in the mirrored maze which corresponded to

correct responses in the original maze pattern argues against this possibility.

Our results therefore suggest that in the rat the engrammic representation for this maze pattern is identical in the two hemispheres with respect to orientation This is contrary to the engram orientation of the two hemispheres which has been suggested by clinical and experimental material concerning the expression of motor patterns in man. The difference might be attributed to a variation in neural development in rats and men, for although Fortuyn (2) and Craigie (1) both concluded from histological studies that the rat has the same cortical laminations as man, there are of course differences in complexity The additional fact that a preferential use of one hand in reaching for food may be shifted to the other hand by appropriate destruction of cortical tissue in the dominant hemisphere, presumably on a preferential basis without observable paralysis, suggests a significant degree of similarity in neural function so far as possible dominance of one hemisphere over another is concerned It was thought, however, that the results reported here may have been conditioned by the fact that maze running is a task involving the entire organism as opposed to the activity of a part, an example of which in human activity would be writing

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THE INFLUENCE OF THE TEACHER'S HANDEDNESS ON CHILDREN'S REVERSAL TENDENCIES IN WRITING

Winifred Day Kirk and Samuel A Kirk

It has frequently been reported that mirror-writing is more common among left-handed than among right-handed children [Beeley (1), Burt (2), Carmichael and Cashman (3) and Gordon (5) One explanation offered for the difference is related to discrepancies between the handedness of the teacher and that of the child [Dearborn (4) and Kirk (7)]. For example, the left-handed child may conceive of writing in motor terms, subordinating visual imagery. It is apparent that if the child whose handedness differs from that of his teacher attempts to reproduce the *motion* made in writing rather than the appearance of the symbol, his result will be a mirrored reversal of the symbol. If the teacher's right hand moves from the center of her body outward, and the left-handed child repeats a corresponding movement with his left hand moving from the center of his body outward, his movement will be the reverse of the teacher's

Hegge, Sears and Kirk (6) report the successful treatment of a left-handed mirror-writer by temporarily changing the handedness of the teacher. It was noted that the child repeated the correct motion, though reversed by the use of her left hand When the teacher shifted to his left hand in writing at the blackboard, the child imitated the motions correctly, forming the letters in proper orientation The authors believed that it was this change which corrected reversal tendencies in the child There has been no experimental evidence, however, to show that the left-handed child does repeat the motion rather than the appearance of letters. Neither has the theory been disproved In an attempt to find evidence either for or against the theory, the following experiment was conducted

Subjects

The subjects consisted of 51 mentally retarded children from the lower educational range of the Wayne County Training School (32 right-handed and 19 left-handed children) and 37 normal and superior children from the kindergarten and first grade of the Elementary School of the University of Michigan (32 right-handed and five left-handed children) The two types of children were similar in mental age and educational standing They were all non-readers or first-grade readers Chronological ages, however, were quite different—showing no overlapping between the ranges of the two types The superior children ranged from four to seven years, the subnormal, from seven and one-half to fourteen and one-half years

Procedure

Each subject was presented individually with both lists of figures shown in Figure 1. Four types of presentation were used, however, and both left-

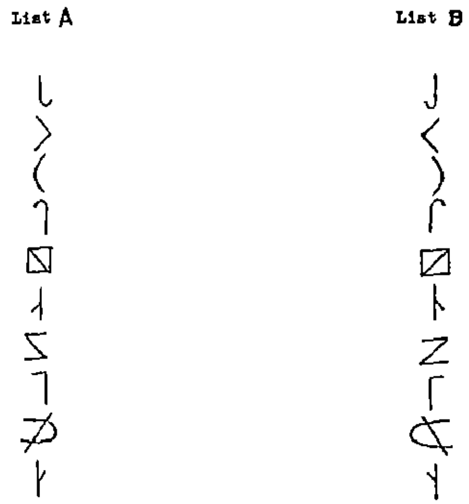

FIGURE 1

and right-handed subjects were divided evenly into four corresponding groups, as follows:

> For subjects of Group I, List *A* was presented with the left hand, then List *B* with the right.
>
> For subjects in Group II, List *A* was presented with the right hand, then List *B* with the left.
>
> For subjects in Group III, List *B* was presented with the left hand, then List *A* with the right.
>
> For subjects in Group IV, List *B* was presented with the right hand, then List *A* with the left.

This grouping was made for the purpose of controlling (*a*) the possibility of the figures presented first influencing the responses to the figures presented last; and (*b*) the possibility of any intrinsic reversability of the figures.

After careful directions had been given to the child, the figures were drawn on the blackboard with somewhat exaggerated motion and in very large size (12 to 18 inches in height). As soon as one drawing was completed, the experimenter stepped in front of it and erased it, while the

child drew what he had seen (The hand spontaneously used by the child was considered his preferred hand.)

Results

The results of all presentations made with the same hand as that used by the child were grouped together and compared with the results of all presentations made with the hand opposite to that used by the child This was possible since the variable factors mentioned above were controlled by the experimental procedure. The results for all right-handed and all left-handed subjects are given in Table 1 (No differentiation here was made between the results of subnormal and superior children, since, as will be seen in Table 2, the slight differences between results were in the same direction for both types)

TABLE 1

SHOWING REVERSALS MADE BY CHILDREN WHEN EXPERIMENTER USES SAME AND OPPOSITE HAND

Hand used by experimenter	Right-handed subjects Same	Right-handed subjects Opp	Left-handed subjects Same	Left-handed subjects Opp.	Total Same	Total Opp
Number of cases	64	64	24	24	88	88
Total number reversals	73	80	23	18	96	98
Mean number reversals	1 14	1 25	96	75	1 09	1.11
$\frac{\text{Diff}}{\text{P E}_{diff}}$		91		1 16		055
% making more reversals than when E uses other hand	33	28	42	21	34	27

TABLE 2

SHOWING REVERSALS MADE BY SUBNORMAL AND SUPERIOR CHILDREN

Hand used by experimenter	All right-handed subjects Subnormal S	Subnormal O	Superior S	Superior O	All right- and left-handed subjects Subnormal	Superior
Number of cases	32	32	32	32	51	37
Average IQ	62	62	120	120	64	121
Total no reversals	28	29	45	51	91	103
Mean no reversals	88	91	1.41	1 59	1 78	2 78
$\frac{\text{Diff}}{\text{P E}_{diff}}$					3 3	

Table 1 shows that for neither the right-handed subjects nor the left-handed subjects was there found a reliable difference between the reversals made when the experimenter used the same hand as the child's and when he used the opposite hand. The data was also analyzed to see if a greater percentage of the subjects made more reversals when the experimenter used one hand than when he used the other. By this criterion the differences are again slight, and even tend to show more reversals when the experimenter used the same hand. When all 88 subjects are grouped together, regardless of handedness, the results are still less significant.

Furthermore, the data on our few cases show no difference between the average number of reversals made by the right- and left-handed children This could be calculated only for the subnormal children since of the normal and superior children only five were left-handed The 19 left-handed subnormals made an average of 1 79 reversals, while the 32 right-handed subnormals made an average of 1 78 reversals

The only reliable difference found was that between the reversals made by the subnormal children as compared with those made by the superior children. These data are presented in Table 2 The slight differences between presentations with same and opposite hands tend in the same direction for both types of children When we compare the mean number of reversals for all subnormal children (1 78) with the mean for all superior children (2.78) we find a statistically significant difference. This indicates that the younger (superior) children made appreciably more reversals than did the older (subnormal) ones. This is very possibly due to the difference in chronological ages, and tends to explain why (in Table 1) the right-handed children seemed to make more reversals than did the left-handed children—all but five of the left-handed children were subnormal. The results tend to corroborate the theory that orientation in reading and writing is based on maturation and experiential factors and has a tendency to improve with age and experience

Conclusions

1. The hand used by the experimenter did not determine reversals made by children of the opposite hand preference Our results offer no explanation of why mirror-writing should be more frequent among left-handed children than among right-handed children

2 Among the small group of subnormal children studied, the left-handed subjects did not make more reversals than the right-handed subjects

3 The younger (superior) children made more reversals than did the older (subnormal) children The indication seems to be that correct orientation in writing is based on maturation or experiential factors or both

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DELAYED RECALL OF PREVIOUSLY MEMORIZED MATERIAL AFTER TWENTY YEARS

MADORAH E SMITH

This study is an analysis of the degree of recall and factors determining the remembrance of portions of material memorized perfectly some 30 years previously and not reviewed or recalled for at least 20 years

The material so memorized was the entire number of 107 answers to the questions in the Westminster Shorter Catechism, a task which the writer began a few days after her eighth birthday and finished during her thirteenth year The method followed was one of distributed practice The task of memorizing one new answer was assigned the child each Sunday but after every ten answers so learned reviews of answers learned so far were interspersed At the time of each recitation the meaning of the answer was carefully explained. After the catechism had been gone through in this manner once, a review followed during which the task consisted of relearning from five to ten answers each Sunday until it was thought that sufficient mastery had been secured to enable the child to repeat at one sitting the answers to all the questions in order This was successfully accomplished when she was twelve years old

The earlier answers were overlearned to a greater extent than the later not only because they were more frequently reviewed in the procedure described above, but also because there was incidental practice in listening

to and hearing the recitations of younger members of the family still in the earlier part of the book and through the nature of the Sunday lesson assigned as a substitute when the catechism had been learned This was the learning of the proof texts appended to the answers As this new task was begun but never finished, the earlier questions again received attention, the latter did not. Exposure to the incidental reviews at home and elsewhere became less frequent upon the child's departure to boarding school and ceased altogether more than twenty years ago. Recently the catechism coming to hand suggested that here was an opportunity to study some factors involved in an unusually delayed recall

Recitation of the answers was therefore again attempted and it was found that 54 or 50 per cent of them could still be given perfectly in response to the questions, 44 more with a little prompting, and the remaining nine answers could be recalled only after considerable help.

As it was realized that the first part of the book had received more practice than the rest and it was noted that the first 11 answers had been perfectly repeated but none of the last 14, the answers were divided into five groups of 21 or 22 each according to their numerical sequence. The percentage of correct answers in the groups in order were 71, 68, 38, 59 and 19 each But the third and fourth groups contained twelve questions asking for the "new commandment," "preface to the ten commandments," and each of the commandments, all of which had received some intervening incidental recall during the period of disuse of the remainder of the material and they were all perfectly known. Not counting these answers then, the percentage of right answers in groups three and four becomes 32 and 17 respectively. Evidently primacy and extra repetitions in the past were an important factor in determining present recall

There is a great variation in the length of the different answers, the number of words in them ranging from eight to 60 words exclusive of the two longest commandments. Separating the answers into groups according to their length and excluding the commandments again, it was found that 73 per cent of those with 20 words and less were perfectly recalled, 56 per cent of those with 21 to 30 words, 19 per cent each of those in the groups of 31 to 40 and 41 to 50 words and one of those which exceeded 50 words in length That there is a relation of present recall to length of answer seems evident.

In answering the questions, considerable help was received both at the time of first learning and at the recent attempt to recall from the fact that in several of the answers some of the words in the questions were repeated with only such changes as are necessary in changing an interrogative sentence to a declarative Accordingly the answers were again separated into three groups, those in which more than ten words of the question were repeated in the answer, those in which five to nine words were, and

those in which less than five were Of the first group, 73 per cent; of the second, 38 per cent, and of the third, only 36 per cent had been perfectly recited. But if we do not include those answers which, although repeating the words of the question, do not do so in practically the same sequence or only after or *when interspersed with* long phrases and clauses, 67 per cent of the first, 54 per cent of the second and 43 per cent of the third group had been still remembered correctly

The answers were next studied to determine the effect of pleasantness and unpleasantness on delayed recall Some of them refer to God's providences, benefits bestowed upon man in this life or in heaven and *salvation Such answers* for one who believed them implicitly as the child did were felt to have a pleasant connotation while those that dealt with duties, "man's estate of sin and misery," the wrath of God and punishment were considered to have an unpleasant meaning Some questions were about evenly divided between unpleasantness and pleasantness and were classed in a separate group. A third classification was of answers that were neutral in tone, mainly those that were purely theological When the answers were thus classified, it was found that 32 per cent of the 41 "unpleasant" answers were remembered, 15 or 52 per cent of the 29 neutral, but only 11 or 73 per cent of "pleasant" were recalled. Of the nine which contained both elements only two were remembered exactly.

Another method of studying this same factor was tried, in an endeavor to separate its effect from that of the other factors affecting the ease of recall To do this each answer was given a difficulty score by assigning a value of zero to those containing 20 words or less and adding one point for each additional ten words or fraction thereof up to 50, plus one point if it was in the third quintile in numerical order of questions and two points if in the fourth or fifth quintiles; plus one score point if the answer repeated from five to nine words, two if less than five words of the question, and an extra point if such repetition was not in the helpful sequence. Results are shown in the following table

TABLE 1

NUMBER OF ANSWERS CORRECT IN RELATION TO DIFFICULTY SCORE

Difficulty score	0	1	2	3	4	5	6	7	
Perfect recall	2	7	13	4	10	5	0	1	42
Not perfect	0	0	2	8	14	12	9	8	53

(The commandments are not included)

When one studied the answers not known, although easy enough to score four or below, and those known, even if scoring three and above, it was found that of the former 64 per cent dealt with unpleasant topics, 28 per cent were neutral and only 8 per cent pleasant but of the latter 42 per cent were

unpleasant, 37 per cent neutral, and 21 per cent pleasant There is therefore an excess of 22 per cent of the unpleasant among the unremembered group and of 13 per cent of the pleasant in the recalled group. One of the answers pertaining to duty yet remembered treated of the sanctification of the Sabbath and was frequently referred to in the home as guide for determining the propriety of various occupations on that day. It might almost have been included in the specially overlearned group. Of the two easiest answers forgotten, one (No 36) lists a series of five phrases describing benefits which have no obvious logical connection and thus presents a difficulty not measured The hardest answer remembered (No 87) was classed as containing both pleasant and unpleasant ideas. Perhaps "repentance unto life" which, although referring to the sinner's sin and hatred of it, is more pleasant than otherwise with its emphasis on a "saving grace" and "God's mercy."

TABLE 2

NUMBERS OF ANSWERS RECALLED PERFECTLY AND THOSE NOT SO RECALLED WITH THEIR DIFFICULTY SCORES

Recalled				Not recalled			
No.	*Score*	*No*	*Score*	*No*	*Score*	*No*	*Score*
1	2	41	1	12	4	71	4
2	2	42	com	13	3	72	4
3	1	43	com	16	5	74	4
4	2	45	com	18	3	75	4
5	2	49	com	19	4	77	5
6	3	51	3	20	3	78	4
7	2	53	com	25	3	81	5
8	2	57	com	26	2	85	5
9	2	60	5	27	5	86	5
10	2	63	com.	33	4	89	6
11	2	64	4	35	4	90	5
14	2	66	5	36	2	91	5
15	0	67	com	38	4	94	7
17	1	68	4	44	3	95	6
21	4	69	4	46	4	96	7
22	4	70	com.	47	5	97	7
23	2	73	com	48	4	98	6
24	2	76	com	50	4	99	6
28	4	79	com	52	3	100	6
29	1	80	5	54	3	101	7
30	1	82	2	55	3	102	7
31	5	83	4	56	4	103	7
32	1	84	4	58	5	104	6
34	3	87	7	59	6	105	7
37	5	88	4	61	5	106	6
39	1	92	5	62	4	107	7
40	0	93	3	65	5		

To summarize this study of recall after over 20 years:

1. Fifty per cent of the originally memorized material which consisted of 107 answers to questions in the Westminster Shorter Catechism was still remembered perfectly and only 8 per cent of the answers required more than a little prompting.

2. Frequency of repetition during the period of original learning, either on account of more frequent reviews, incidental outside contact, or special stress at the time of learning as in the case of number 60, was an important factor in determining which answer would be recalled.

3. None of the material which received incidental recall during the 20 years of no practice was forgotten.

4. The ease of the answer as determined by its length and the number of words from the question repeated at the beginning of the answer was another factor determining recall.

5. Those answers with the pleasanter connotation were better remembered than those with an unpleasant significance.

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NOTICE CONCERNING DISCONTINUANCE OF FOREIGN LANGUAGE ABSTRACTS

CARL MURCHISON

Because of the general lag in publication, and the relatively large amount of total space occupied by foreign language abstracts, we have decided to discontinue the publication of these French and German abstracts. We will publish such abstracts as have already been arranged for, but will be unable to prepare additional ones. This change in policy will release for publication purposes approximately 100 pages of space, annually, in the various journals under this editorial supervision.

Clark University Press
Worcester, Massachusetts

BOOKS

CARL MURCHISON [Ed.] *A Handbook of Child Psychology* (2nd ed, rev.) Worcester, Mass · Clark University Press, 1933 Pp xii+956

The first edition of the *Handbook of Child Psychology* was an enormously important contribution It presented a summary of an amazingly rich collection of scientific studies, the material of which was but imperfectly known by psychologists generally, and the very existence of which had hardly been hinted at, even, by the rather popularized elementary textbooks which were, at least until that time, the only general presentations of the work in this field In fact, the first edition was such a very significant landmark in the history of child psychology that one might be forgiven for attempting to rewrite the story of Cinderella, taking the field of child psychology as the modern Cinderella—hard-working, faithful, and skilled at many tasks, though sneered at by her haughty sisters in psychology and compelled by them to sit in the corner of the kitchen—and casting the editor and authors of the *Handbook* as the fairy godmother who arrays Cinderella in garments befitting her excellent nature, thus producing a recognition of her real worth

But if the first edition was Cinderella after her fairy godmother first decked her out, the second edition is Cinderella after the fairy godmother had sent her to college, fed her on spinach and vitamines, and gathered together some additional good qualities which even Cinderella herself did not realize that she possessed, and which the godmother previously overlooked because there was so much else to do in the excitement of getting the young lady to the ball for the first time. There are few books that a psychologist might own which would do more to keep him abreast of the work in his field than the one under discussion The more recent *Handbook of General Experimental Psychology* and *Handbook of Social Psychology* are even larger volumes; but if one were to remove from these three books the material contributed by biologists and physiologists, it is not at all sure that the present volume would take even second rank with respect to the quantity and quality of scientific work—and work of general psychological interest, at that—represented in them

MAIN CHANGES FROM THE FIRST EDITION

The decided increase in length is the first change that impresses one The first edition was no slight volume, but the second edition, taking into account the increase both in the number and in the size of the pages, has had the actual text increased by approximately 43 per cent

The second change one notices is that the 24 chapters of this edition have

been grouped into five parts dealing respectively with the methods of child psychology, the development of behavior before birth, the development of behavior after birth, factors that modify child behavior, and studies of special groups This new mechanical feature of the book has decided value, for, in the main, the chapters fall legitimately into these five divisions, and it helps the reader to see the material in proper relationship when this organization is given.

The most important modification, however, consists in the changes in the composition of the *Handbook* In fact, one would be about half justified in speaking of this edition, not as a revision, but as a new book, because eight of the 22 chapters of the first edition have been eliminated, and ten new chapters, occupying 48 per cent of the space in this second edition, have been substituted for them Of these new chapters, three are to some degree substitutions for certain chapters omitted in the revision, but even disregarding these three, the other seven new chapters comprise 37 per cent of the new edition. A stronger and better-balanced volume has been produced by these changes. Nevertheless, the chapters omitted had considerable merit, and if they give the first edition of the *Handbook* a continuing usefulness this fact would not be at all surprising To those who are familiar with the first edition this will be apparent from the following list of the chapters omitted

"Eating, sleeping, and elimination," by Helen T Woolley,
"The experimental construction of an environment optimal for mental growth," by Susan Isaacs,
"The developmental psychology of twins," by Arnold Gesell,
"Physical growth and motor development and their relation to mental development in children," by Beth Wellman,
"Children's drawings," by Florence Goodenough,
"Children's plays, games, and amusements," by Helen Marshall,
"Children's dreams," by C W Kimmins,
"Psychoanalysis of the child," by Anna Freud

The preface to the second edition explains these omissions by saying that "Chapters on topics not subjected to continued research have been omitted." This may indeed account for several chapters. However, it would seem that a more important reason, with some of the chapters at least, was that they were too restricted in scope The topic of children's dreams, for example, is an interesting one, but, as a subordinate part of the phenomena of personality in children, it is by no means coordinate in scope with the other chapters So likewise with a number of the other chapters omitted

The chapters that have been added are scattered through all of the five parts except the first. However, it will be noticed from the following list of new chapters that the topic which has received most additional

stress is the topic of prenatal and infant development. Not only do four of the new chapters deal principally with this period, but it is to be noted in addition that the chapter by Carmichael is so extensive that it occupies one-seventh of the space in the book, instead of the one twenty-fourth that might be considered its nominal share The added chapters are

"Origin and prenatal growth of behavior," by Leonard Carmichael,
"The neonate," by Karl Pratt,
"Maturation and the patterning of behavior," by Arnold Gesell,
"Locomotor and visual-manual functions in the first two years," by Mary Shirley,
"The measurement of mental growth," by Florence Goodenough,
"Sex differences," by Beth Wellman,
"Speech pathology," by Lee Edward Travis,
"The physiological appetites," by William E Blatz,
"The child with difficulties of adjustment," by Phyllis Blanchard,
"The adolescent child," by Leta S. Hollingworth

These omissions and additions are not the only changes in content, however All of the fourteen chapters carried over from the first edition have been revised to some extent, except the chapters by Piaget, Kluver, and Margaret Mead. The extent of these revisions is indicated with some measure of accuracy by the fact that in the eleven chapters that have been revised, the number of references listed has jumped from 860 to 1382 However, the amount of change differs greatly in the various chapters In certain cases the only changes were the insertion of brief discussions of a few new references. Other chapters have been worked over very completely—particularly the chapters on "Emotional development" by Mary Cover Jones and on "The gifted child" by Lewis M Terman and Barbara Burks Fairly extensive changes have been made in the chapter on "Children's morals" by Vernon Jones Further comments on these changes will be made below in discussing the individual chapters

Discussion and Criticism of the Individual Chapters

This section of the review will not aim at completeness As already noted, about half of the chapters in this edition remain at least in great part as they were in the first edition These will receive relatively little comment here, both because many psychologists will already have formed first-hand impressions of them, and also because the first edition received a rather full and exceedingly splendid review by Barbara Burks (*J Genet. Psychol*, 1932, 41, 240-248) Any reader who desires a full discussion of this second

edition is advised to refer to Miss Burks' review also, because the following comments are intended to supplement her earlier comments rather than to repeat what has previously been said Even with this restriction, however, there will hardly be space for the citation of evidence to support the evaluations made, and the review will have to be rather dogmatic in character The chapters are discussed in the order of their occurrence in this edition

Part I is composed of the rather mechanical and uninspired chapter by John E Anderson on "The methods of child psychology" In the revision, a few insertions of new material have been made (as, for example, some new citations of discussions and illustrations of methodology, and brief discussions of psychoanalysis and of factor analysis as methods of child psychology), but except for such minor changes the chapter stands unchanged At scattered points Anderson's comments are highly cogent, but at quite a few other points (see pp 8-9, for example) the discussion is wabbly and even misses the essential points entirely. The chapter would be considerably improved if it were overhauled thoroughly from the standpoint of the clearness and precision of its thinking The organization would be much improved if the discussion of particular methods, which occupies the largest part of the chapter, had dealt separately with the methods related to what the author describes as the two fundamental methods of approach in research in child psychology—the normative approach on the one hand, and the law-yielding or nomothetical (what he unwisely calls the "experimental") approach on the other hand His consideration of these two things together results in jumbling the discussion somewhat, and in slighting rather seriously the methods related to the normative approach. Another weakness of this section is that the methods are discussed without relating them to the problems on which they are used As the chapter stands, it contributes little to the purpose of the volume to minister to the needs of those already fairly well at home in child psychology

Part II is composed of the single new chapter by Leonard Carmichael on the "Origins and prenatal growth of behavior." The chapter is a very capable and scholarly piece of work, and gives a careful and critical review of a great range of important experimental work The first two-fifths of the chapter describes the work on infra-human development, discussing in successive sections the lower vertebrates, birds, marsupials, rodents, and cats The remainder of the chapter discusses human fetal development, giving a history of theories regarding the nature of prenatal development, and discussing successively the means of expressing and estimating fetal age, the general bodily development of fetuses, non-operative studies of behavior development in fetuses, studies of behavior in operatively removed fetuses, the special senses in human prenatal life, and the question of what

factors cause the development of prenatal behavior. The chapter is not an easy one to read, crammed with factual material as it is. However, the material is of considerable significance because of its bearing on a number of important and highly controversial subjects in psychology, and the chapter richly repays anyone who works through it The only serious adverse criticism is that no treatment is given (except in connection with the problem of breathing responses) to the question of what effect chemical factors have on the behavior of the fetus and, indirectly, on behavior in later years. Just as textbooks in embryology have so consistently restricted their discussions to anatomical structure and have neglected the physiological aspects of development, so it is understandable that psychologists would tend to think of fetal behavior in terms of reactions to stimuli, and would neglect the possible influence of chemical factors. There is enough known to suggest that such influences are exerted, and the problem is important enough as a research field to have warranted the presentation of what knowledge there is

Part III, on "Development of child behavior after birth," is the longest division of the *Handbook*, its ten chapters comprising 42 per cent of the total The chapters within this division are arranged at least roughly in the order of complexity of subject matter, the early chapters being concerned largely with maturational effects, and the later ones dealing with behavior that involves more and more the influence of cultural factors

The first chapter in this division, by Karl Pratt on "The neonate," is so closely allied to Carmichael's that it may be well to speak in terms of the comparison between them. Of the two, Pratt's chapter is somewhat more readable, but less complete in its utilization of available material, and somewhat less mature in its critical evaluations and general theory Its discussion of neonatal sensitivity is thorough, but its description of the reflex equipment and patterns of response of the neonate is rather sketchy On the latter topic the serious reader would do well to supplement this presentation with several articles by Wayne Dennis in the last few years A few scattered corrections are needed, as in the statement implying that the galvanic skin reflex is not to be observed in the first year, and in the statement that the Russian physiologists have maintained that conditioned reflexes cannot be established below the age of about three to five months In the main, however, the chapter is a very good piece of work, and is a definitely valuable addition to the *Handbook*

Arnold Gesell's "Maturation and the patterning of behavior" overlaps in a few respects some of the material in the chapter in the first edition by the same author, on "The developmental psychology of twins" However, the main purposes of the two chapters are different, and the largest part of the material in the first edition is not included in this. Here one finds primarily a general disquisition on the principle that the "manifestations of

development . . . come from inner compulsion and are primarily organized by inherent inner mechanics and by an intrinsic physiology of development" (p 232) The chapter can be divided into four main divisions dealing respectively with (1) the definition of such general terms as development, growth, maturation, and learning, (2) general biological principles regarding the rôle of the genes, and of maturational factors generally, as determinants of physiological development, (3) maturation as the basis of much of the development of behavior in infancy, and of learning, intellectual development, and affective life *in later years*; and (4) *maturation as a* regulating factor operating to prevent unusual environmental influences from producing too unusual deviations from the norm Gesell's general argument is good, but it suffers from being carried too far, as when he declares "However potent and pervasive social environment may be, basic *organization of the higher thought processes is probably determined by* primary ordering factors within the growing organismic pattern" (p. 226). Such may be the case, but such a jump is necessary from his evidence to this conclusion, and his discussion is so empty of any suggestions for research whereby the conclusion could be given more meaning, that one suspects such statements rest only on the enthusiasm of the author for the general concept of maturation. The evaluation of this chapter is difficult. *One warning that should be given is that many of its sentences need to be* read and re-read before their meaning emerges surely (and even then the haze does not always clear) The most serious weakness of the chapter is perhaps the fact that it has, to too great a degree, the nature of a discussion designed to prove a general proposition. It does not yield many suggestions for experimental investigation, and does not consider any of *the arguments or evidence opposed to the point of view it defends.*

Mary Shirley's chapter, "Locomotor and visual-manual functions in the first two years," is devoted principally to two topics, the discussion of which is considerably intertwined development of infant behavior from the standpoint of *norms* of development, and development of behavior from the standpoint of the *sequence* of development Of the two topics, it is the second which *receives the more prominent consideration. Shirley makes the* interesting observation that the biographical studies of infants, although of course inadequate as means of securing norms of development, nevertheless contribute almost the only studies available on the sequence of infant development The data from these biographical studies are organized and presented in relation to the corresponding data from the studies by Shirley and by Charlotte Buhler. Considerable attention is given also to *some specialized studies of the development* of hand reactions and of walking This chapter is another fine addition to the *Handbook* It is easily read, has well-digested presentations of experimental work, and seems very sound in its general interpretations This chapter, together with Car-

michael's, affords an interesting answer to the frequent assertion that the maturation doctrine is more or less inevitably an obstruction to research.

Mary Cover Jones's "Emotional development" is a very considerable revision and improvement of her chapter in the first edition on "The conditioning of children's emotions" Her discussion concerns these topics: the problems of what the primary emotional patterns are, and whether there are any unlearned emotional responses; the development of emotional responses through maturation, the simpler experiments on emotional habits; the nature of the situations that are evocative, and the nature of the responses made, in the case of different specific emotions in children, the relation of internal and overt expression of emotion, and, finally, personality-test studies of emotional stability and of delinquency. The material on these topics is covered clearly and effectively, but the value of the chapter is limited through the circumstance which she characterizes very well in her summary:

> . although the era of speculation . . . has given way to a period of extremely active empirical study, our methods of investigation are still in a relatively crude state and we still have numerous controversial issues which do not yield readily to experimental attack (p. 298)

As the author states, her discussion is devoted principally to the theoretical aspects of emotional development rather than to the practical aspects, the latter being reserved for the chapter by Phyllis Blanchard on "The child with difficulties of adjustment" In addition, however, the author has limited her treatment in still another respect, by virtually restricting her discussion to laboratory experiments, simple observational studies, and testing studies. The consequences of this restriction is that there is a considerable gap—in fact, almost a chasm—between her chapter and Blanchard's. This gap would have been smaller if she had discussed a number of problems that rest at least on good clinical evidence and which are very important for the envisagement of the theoretical problems of emotional development. There is no discussion, for example, of the significance of emotions as forms of motivation, or of the principle of substitute response in emotional behavior (except for an incidental comment in the discussion of jealousy), or of the more complex phases of emotional development The discussion suffers somewhat from the fact that the author seems still too entranced with the conditioning theory of learning She disavows any reason for using conditioned-response terminology except that of convenience, but no material is given which indicates any inadequacy in the traditional conditioned-response interpretation of emotional development

The new chapter by Florence Goodenough on "The measurement of

mental growth" is one of the high points of the volume It deals with the more fundamental problems of mental test construction and interpretation, and with the interpretation of the results which have been secured on such matters as the curve of mental growth, the predictive value of test scores, and the intercorrelation between different traits. In other words, Goodenough has made no attempt to give a catalog of what mental tests have been devised, how adequate their standardizations were, or by whom or for what purposes they have been used. Rather, she has discussed those problems which a person must understand in order to possess a mature and critically sound understanding of research on mental tests, and which one must take into account in planning research that uses mental tests as a tool A somewhat smaller number of references are cited than in many of the other chapters, but the references used were chosen with great discrimination, and represent those studies that have been particularly significant in contributing to such a sophisticated understanding of mental test work A few of the topics in the chapter might well have been developed more fully, but taken as a whole, this is the most distinguished piece of work, from the standpoint of theoretical adequacy, in the whole volume

The succeeding chapter by Dorothea McCarthy on "Language development" is another very fine contribution In its style it is more like Carmichael's chapter—careful, thorough, very compactly written, and well organized. It covers a great range of research, and does it well In the revision this chapter has been carefully worked over, both as regards additions of new material and as regards many details of expression and of organization.

The excellent chapter by Charlotte Buhler on "The social behavior of children" has been enlarged by the addition of new material at scattered points, but otherwise is unchanged The only serious adverse criticism that can be made of this discussion is that it draws almost exclusively on German and Austrian studies for its material. A valuable complement to it is found in the section on social behavior in Stoddard and Wellman's recent "Child Psychology" The latter is also a careful and stimulating discussion (and fortunately is one of the more readable portions of their book), and the American studies of social behavior in children are the ones stressed by it These two papers on the early development of social behavior present a wealth of material which will prove of arresting interest not only to child psychologists, but to social psychologists as well.

Joseph Peterson's "Learning in children" is a chapter which has been revised with the aid of the grafting knife, but which should have been revised with the pruning hook or the axe Its pages are cluttered with dead wood, and it has little justification for being the second longest chapter in the book Learning is an important topic, of course, in child psychology;

but it should be remembered that the subject of learning is considered at perhaps a dozen other places in the book, as in the discussions of emotional development, language development, social behavior, speech pathology, and behavior difficulties With the material on learning in these special fields thus eliminated, there is not a great quantity of work of high scientific value remaining for this discussion It is chiefly the lavish use of space which causes this chapter to be so long Very detailed descriptions (up to four pages for a single study) are given of experiments that employed such small groups that the results have little significance. And in a number of these cases, the results are given both in tables and in graphs Such a practice may be desirable in original reports (though with studies of as low reliability as many of these, even this is questionable), but the duplication does not belong here. Or again, in describing the disc-transfer problem, a full half-page is taken for a cut showing that a board is used which has three circular areas on it—as though the nature of the thing could not be grasped from a few simple words in the text! A full page is devoted to a table showing the reactions of a college sophomore on Peterson's rational learning problem—more space that tells the reader nothing that he would not have expected after reading the description of the nature of the problem. Another page is given to a table showing the age norms for the rational learning problem as administered in a form which Peterson abandoned in 1923. A half page is given to a cut showing the learning curve on this problem of 19 subjects—age, race, educational status, and everything else unspecified Still other instances might be noted. And yet, surprising in view of this generous use of space, much of the significant material on learning in children is not considered For example, there is nothing on studies of conditioning in children either by American or Russian workers, nothing on reminiscence in children, no mention of some of the classical experiments on transfer of training, and no mention of Gates's study of the influence of active recitation. There are some good sections, such as the summary of Hazlitt's check of Piaget's experiments on thinking, and the very good summary of Woodrow's experiment on learning in normal and feeble-minded children of the same mental age, but as a whole the chapter is distinctly unsatisfactory

Vernon Jones's chapter on "Children's morals" is, appropriately enough, a very conscientious piece of work, and affords a very excellent survey of objective-test studies of moral behavior The chapter, however, is not equally fine in some of its general theoretical aspects, although this portion of the discussion has been improved in the revision Serious objection can be made to the treatment given the material on the relation of intelligence, age, sex, race, and nationality to individual differences in morality In the section on "Influence of intelligence," for instance, material is presented showing that Terman's gifted children ranked higher on character tests

than did the control children, that the 4000 delinquents reported by Healy and Bronner had an average IQ of only 90, etc. No mention is made of the superior environments which the gifted children had, nor of the social, racial, and other factors affecting the IQ's of Healy's subjects The discussion is qualified only by the concluding paragraph of the section, which states definitely that the preceding discussion was not intended to imply that differences of intelligence were causally related to differences in morality. The treatment of the influence of age, sex, race, and nationality is analogous. Now, no objection can be made to this material in itself. It is good material for introducing a discussion of these factors on morality. But, why was material of this sort, developed no further than it was, placed in a division headed "Nature's contribution to individual differences in morality"—a division which begins, moreover, with the sentence. "Having considered the individual differences which exist in moral behavior, we are immediately faced with the problem of the causes of these differences"? If these sections were not intended to imply any causal relationship, why were they put in a division thus headed and introduced? And still further, why does the discussion not continue into the problem of whether these various factors *are* causally related to morality? The heart of scientific inquiry does not consist merely in determining relationships, but consists in determining *essential* relationships Moreover, there are good data, as for example in Healy's material, to answer the question as to whether causal relations do exist here. In view of these limitations, it might be well to mention that a good supplement to this portion of Jones's chapter is to be found in the discussion of delinquency in Curti's "Child Psychology" Another of the less satisfactory features of this chapter is that the problem of morals is treated in relative isolation from the other phases of personality (there is no mention, e g, of the frequent relation between neuroticism and scrupulosity) This separation is a typical weakness of discussions of moral behavior; but in a psychological discussion it is particularly desirable to get away from this old limitation. Perhaps part of the reason for this shortcoming is that the author confines himself so largely to objective test data, and draws on case studies only for their general statistics and conclusions regarding the influence on moral behavior of various environmental factors The last part of the chapter discusses motivation and learning in relation to moral behavior, but the discussion in this section depends in good part on speculative works and on experiments which only by extrapolation could be considered as bearing on moral behavior

The last chapter in Part III is Jean Piaget's brief account of "Children's philosophies," which has not been revised. It is difficult to see why this chapter was left unchanged. In the first place, although its material (a summary of Piaget's findings on realism, animism, and artificialism) is interesting and significant enough, this part of Piaget's work is hardly

more significant than many other parts The discussion would not have encroached on the other chapters, and would have been much more deserving of its place in the *Handbook*, if it had covered the broader topic of "The nature and development of children's thinking" Furthermore, if Piaget is not interested in relating his observations to the work and criticisms of others, it would seem desirable to secure an author who would give a more complete and critical account of the work on children's thinking. There is enough evidence to indicate that some of Piaget's own conclusions are in need of critical re-evaluation

Part IV, "Factors that modify child behavior," opens with the masterful chapter by Harold E Jones on "Order of birth" The author reveals clearly and skillfully the dangers of interpretation involved in research on this topic, and uses this analysis very capably to evaluate the welter of evidence available The conclusions of the discussion are negative, but positive notions are so common both in clinical discussions and in lay thought that it is important to have these negative conclusions established so carefully. The revisions in this chapter are minor ones.

The next chapter, by Kurt Lewin on "Environmental forces," is likely to occasion at least as much controversy as any other in the *Handbook* Unfortunately, its placement in the volume will probably tend to increase the confusion apt to characterize this controversy, and many of the remarks by Lewin are likely to operate in this same direction. What I refer to is the fact that this chapter is not at all a discussion of "environmental forces" in the sense in which this expression normally would be understood, and that, moreover, the purpose of this chapter is essentially different from that of the others in Part IV It deals with environmental factors only in the sense of a set of symbols representing not only the physical and social environment of the child *as perceived by the child*, but also the motivations and meanings ordinarily thought of as existing *within* the child Lewin's purpose is not that of summarizing what is known regarding the influence of even this broader range of factors, but is rather the aim of presenting a conceptual system which he believes will facilitate the problem of understanding and investigating the reactions of children to specific situations The reactions of many psychologists to this discussion doubtless will be unfavorable It will be said that all of Lewin's principles can be expressed adequately in the familiar terms of the nature of the external situation, the motivations of the child, the child's conditionings toward his environment (or the meanings which the environment has for the child), etc—and that, in short, although some of the experiments which he describes are ingenious, the conceptual system which he erects is but an awkward translation of more generally used principles The answer to such criticisms which occurs to me, and which I think might well have been presented in this chapter, is that Lewin's system possibly has the merit of enabling one to deal with

complex situations as wholes by its reduction of qualitatively different things to commensurable terms. Psychologists of all schools are quite ready to agree that behavior cannot be adequately described unless it is considered as a reaction to the total situation, but practical difficulties arise when one tries to think in terms of such "total situations." These difficulties are the things that give Lewin's concepts their possible value, for it may be that his procedure of translating motivations into environmental forces (or, more specifically, "valences"), meanings into "distances," "directions," and "barriers," etc., will give a conceptual system which will facilitate this important, but ticklish, task of visualizing the total situation in which any reaction occurs. Lewin does not defend his system in this manner, but depends rather upon the description of a number of experiments and observations by himself and his students that illustrate the meaning, and tend to demonstrate the methodological effectiveness, of the way of thinking about child behavior which he has developed. A much more appropriate setting for this discussion would be a part which might very well be created on "Main ideological and methodological systems for the study and description of child behavior." It should be mentioned, last of all, that this chapter has been revised rather extensively, chiefly with the intent of making the principles clearer, and also by the addition of new illustrative material.

The new chapter by Beth Wellman on "Sex differences" is a relatively brief, but very able summary. The plan of the chapter is distinctly different from that of the others. With each sub-topic, Wellman states the conclusions that seem warranted on the basis of the available evidence, and then cites in lump fashion the group of references from which the conclusions were drawn. This plan compels one either to take on faith, or else to search out for oneself, the evidence for the conclusions given, and therefore has disadvantages in comparison with the laborious demonstrations of H. E. Jones. However, considering the relative uniformity of the results in this field and the great number of relevant studies, one can but be grateful to the author for choosing this style.

The new chapter by Lee Edward Travis on "Speech pathology" is another discussion that seems misplaced. For, of course, speech pathology is not a general factor modifying child behavior, like birth order, sex characteristics, or physiological appetites, which are present in all children, but is on the contrary something that characterizes a small minority of children. In addition, Travis makes very little effort to show how speech difficulties affect the rest of a child's life. His material is presented as bearing on the specific processes and problems of speech pathology. Part III would therefore seem to have been the more appropriate section for this discussion. However, Travis' chapter is undeniably a worthy addition to the *Handbook*. It is especially ample in the matter of evidence tending to support the

neurological interpretation of stuttering The chapter seems out of proportion in a few respects, however. No mention is made of the fact that stutterers typically do not stutter when they are by themselves or in situations in which they have full confidence. Such facts do not necessarily disprove the evidence of the neurological studies, but they are important nevertheless in indicating that probably any neurological explanation must be qualified by a consideration of other factors as well Such omissions can hardly be excused on the grounds of lack of space, because, for example, a rather appreciable discussion is devoted to aphasia and other speech disorders resulting from neurological lesions Except in very rare cases, it is hard to see how such material belongs in this chapter, unless Travis intended to deal with the second childhood as well as with the first.

Heinrich Kluver's chapter on "Eidetic imagery" is unchanged except for the addition of one reference This is another chapter that has received a rather questionable placement, because Kluver sees no reason for discussing eidetic imagery from the standpoint of its possible significance for child behavior or child education, but treats it simply as an observed phenomenon which characterizes some children.

The new chapter by William Blatz on "The physiological appetites" will prove a surprise to any reader who infers from the title that the discussion will draw heavily on physiological research Such is not the case. The discussion does concern what Blatz calls the six principal physiological appetites—hunger, thirst, elimination, rest, change, and sex—but, except for fleeting comments, the consideration of these is psychological and practical, rather than physiological Perhaps the best characterization of the chapter is given in the last paragraph, in which Blatz speaks of the material presented as a "plan of training," and as a "clinical philosophy" Such being the case, this chapter corresponds somewhat to the one by Helen Woolley in the first edition It is broader in scope, however, both as regards the number of motives considered and in the adequacy with which these appetites and their influence on activity are treated One flaw in the chapter is its lack of conciseness Furthermore, some of the minor points seem dubious —as for example, the argument on p. 729 that a child's enjoyment or dislike of a food is not the factor that controls his behavior, but that likes and dislikes are the result of approaching and withdrawing attitudes that have been set up by past training (I presume that this is the James-Lange theory of emotion, in disguise). As a whole, however, the chapter shows the results not only of intelligence and good sense, but also of extensive practical experience in work with infants and preschool children

Part V of the Handbook, "Studies of special groups," opens with a chapter on "The gifted child" by Lewis M Terman and Barbara Burks This is a very considerable enlargement of Terman's chapter on the same subject in the first edition. The changes consist mainly in the inclusion of sum-

maries of material from a much greater number of studies of gifted children, and of an extension of the discussion of the education of gifted children and of the significance of studies of gifted children for the interpretation of genius The chapter is a well-balanced and very capable piece of work.

Rudolf Pintner's valuable, chapter, "The feebleminded child," stands almost unchanged, the only alterations in the text being those on pages 814, 829, 830, 834, 835, and 836, each change, being only the addition or change of a sentence Somewhat more ample additions might not have been out of order The recent book by Doll, Phelps, and Melcher on "Mental deficiency due to birth injuries," for instance, gets only the passing recognition of this sentence "Birth injuries may sometimes lead to mental deficiency according to Doll *et al*" (p 834) If Pintner was aiming at brevity, it is difficult to see why he inserted anything but the number referring to this item in his bibliography, for the sentence says nothing not contained in the title of the book

Leta S Hollingworth's "The child of special gifts or special deficiencies," was in need of drastic revision, but it stands virtually unaltered. The chapter is not up to the level of the rest of the book It is written as though the reader were not expected to understand the meaning of a correlation coefficient; whereas, of course, if this typified the preparation of a reader, heaven help him with the rest of the volume! There are quite a few statements in the chapter that seem highly questionable and even objectionable Some examples are the following.

> The IQ . . . is the quantitative statement of the amount of general intelligence, or *g*, which characterizes any child (p. 843)
>
> Ability in problems can probably not be greatly affected by drill, since "a problem" is, by definition, something that requires adjustment and not the response of automatic habit It therefore calls on general intelligence and cannot be improved after the mechanics of reading and of calculation have been mastered up to the limits of capacity. (p 851)
>
> "Social intelligence" is, in all probability, not a specialized set of mental functions, but merely an optimum section of the curve for *g* (determined by ratio to the median intelligence of the led), combined with certain physical and temperamental traits. (p 853)

It is true, as Hollingworth says in the early part of her chapter, that the investigation of these special abilities and disabilities has not been extensive yet, but at least there is material which demands a much more adequate treatment than the present one

The new chapter by Phyllis Blanchard on "The child with difficulties of adjustment" discusses the causation and treatment of delinquency and of emotional maladjustments in children This chapter has a number of correspondences with that in the first edition by Anna Freud on "Psychoanalysis of the child," for in addition to some natural similarity in subject matter, there is some appreciable resemblance in interpretations Blanchard's discussion reveals that she is highly conversant, as well as sympathetic, with the psychoanalytic methods and concepts. As a matter of fact, in discussing the causes of delinquency she shows perhaps too much tendency to rely on psychoanalytic explanations, and does not have enough of a sociological or social-psychological approach to these problems. Little attention is given to the rather considerable evidence that a great deal of delinquency is due to the meanings, or definitions of situations, which some children very normally possess as a result of the influence of their social environment Another difficulty with this chapter is that there exists too great a gap between it and the chapters on emotional and social development which should have led up to it Of course, several remedies will suggest themselves for this gap. Probably a number of psychologists will feel, "Why not get someone to deal with this problem who won't dabble around in the tangle of psychoanalytic principles, but who will stick to a straight psychological interpretation of difficulties of child adjustment?" The difficulty with this suggestion is that, among those workers actually dealing with adjustment problems, there has been a steady and increasing trend toward the utilization of psychoanalytic principles, whether expressed in the orthodox terminology or translated into some new set of terms Such being the case, it would be both presumptuous and unwise for workers in general child psychology to insist that their concepts should be used in this much more complex field of personality difficulties The solution of the problem would seem to me to be rather to recognize the existence of this gap as indicating a real need for another chapter in the Handbook Both from an ideological and methodological standpoint psychoanalysis represents such a distinctive and important approach to the problems of child psychology that it might reasonably be given more definite representation The chapter by Anna Freud, however, hardly met this need, nor perhaps would any chapter written by any regular psychoanalyst, because they are too contemptuously negligent of academic psychology to know how to integrate their work with ordinary child psychology And that is what would be needed most in such an additional chapter—to show resemblances, conflicts of principle, etc The chapter should be written by someone who has a sympathetic understanding both of psychoanalysis and of those portions of child and general psychology bearing on similar problems, and who also is able to view both fields objectively and critically It should include at least an elucidation of child-psychoanalytic methods and principles, a criticism

of these in the light of general psychology and in the light of ordinary logic (see, e g., the review by R R Willoughby of Melanie Klein's "The *Psycho-analysis of children,*" *J Soc. Psychol, 1933, 4, 257-260*), and a criticism of ordinary child psychology in the light of psychoanalytic work. Blanchard does accomplish these purposes to some degree, but her responsibilities to the topic of the chapter preclude her giving the more comprehensive view of the problem which seems to be needed.

Another new chapter is Leta S Hollingworth's on "The adolescent child." The chapter is virtually a condensation of her book, "The psychology of the adolescent," and has the virtues of that simply written, but very wise, discussion In other words, the discussion is centered around the main problems of adjustment that the adolescent has to accomplish, rather than being organized primarily with reference to what topics have been given extensive research development.

The last chapter of the book is the stimulating one by Margaret Mead on "The primitive child" It is unchanged from the first edition

General Criticisms of the Handbook

The first general criticism which is demanded by a volume such as this is a criticism of its choice of topics and distribution of emphasis. A number of comments have already been made on this matter, and need not be repeated One further suggestion, however, is that it is very surprising that the part on "Factors modifying child behavior" does not include a chapter on hereditary influences

A second general criticism concerns the type of treatment given the various topics by the different authors A diversity of types of treatment is present in this volume, as has been noted above In the main, this diversity is not an undesirable characteristic, because, despite the differences, almost all of the chapters have been mature and scholarly pieces of work, and the different topics, moreover, demanded rather different styles of treatment In some fields the possible research problems have been fairly completely mapped out and developed. In such fields, of course, the style of treatment can be mainly that of the historical summary In other fields the situation is different and demands another approach.

However, although considerable diversity in style may be legitimate, the *Handbook* would be definitely improved if there could be a rather general shift in style in many of the chapters in the direction of providing a richer theoretical setting for the discussion of specific past research It is true of most of the divisions of child psychology, as a number of the authors have remarked regarding their specific fields, that many of the most important hypotheses are as yet untested, and perhaps to date are not even generally recognized as problems needing investigation Such being the

case, what would seem desirable with each topic would be to place the summary of past work in the framework of a critical discussion, first, of the methodological principles of that particular field, and second, of the issues which, on the basis of all direct and indirect evidence, seem to be the ones on which research ought to be done in order that the field would be adequately developed. Child psychology, despite all the work that has been done, is still far from being a finished science Such being the case, the good child psychologist is not the person whose mental equipment is composed solely of knowledge of the past research in the field, but is the one who is able to see, as well, the gaps in this research and the means whereby these can be filled

It perhaps would be a risky thing for the *Handbook* to try to develop in this suggested direction, because the technique for describing and evaluating past research has become much more standardized and dependable than perhaps can ever be the case with the task of formulating the hypotheses that are needed to round out fully the development of any topic. If the style of treatment could be developed in this direction, however, it might considerably increase the value of the *Handbook*, because it would promote a better understanding of past research studies through assisting the reader to see them in proper perspective, and it would, as well, afford considerable stimulation and guidance for further research

This *Handbook* is not perfect. There is still room for development and improvement. However, it would be a mistake to end on a negative note, because the reading of the *Handbook* itself leaves one with quite a different impression—an impression of deep respect for this solid and scholarly piece of work There is no doubt but that the reading of this volume will richly repay those psychologists whose interest is serious enough to make them willing to read and ponder its pages

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